Vol. XVIII.
No. CCCCXXXIV.

MARCH 19, 1886.

Price
Fourpence.

THE ELECTRICAL REVIEW

LONDON: PUBLISHING OFFICE, 22, PATERNOSTER ROW, E.C.—Subscription per annum, Postage inclusive, in Great Britain, 12s. 6d.; to Countries in Postal Union, of the first class, 21s. 8d.; of the second class (Aden, India, Persia, &c.), 23s. 10d.—New York: D. Van Nostrand, 23, Murray Street, and 27, Warren Street. Paris: Madame Veuve J. Boyveau, Librairie Etrangère, 22, Rue de la Banque. Berlin: A. Asher & Co., 5, Unter den Linden.

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Electrical Review.

VOL. XVIII.—No. 432.

THE ELECTRIC LIGHTING ACT.

THE subject of electric lighting legislation is once again receiving attention, and not unreasonable hopes are entertained that the grievances under which the industry has laboured so long will now be speedily redressed. Nearly a year and a half have passed since Mr. Chamberlain, replying to the urgent representations of Sir Frederick Bramwell and others, expressed himself rather positively against the repeal of the "compulsory purchase clause" in his Electric Lighting Act; and in the interval many changes have taken place. The "ins" have been "out" and now are "in" again; but Mr. Chamberlain is not now President of the Board of Trade, is, indeed, according to a rumour which reaches us as we write, no longer a member of the Ministry. Very little has been done since that date in the shape of public lighting, and the sole blame has been laid, rightly or wrongly, upon Mr. Chamberlain's shoulders. Possibly the period has been sufficiently long to allow of a modification in the views which that gentleman then held; it has not been long enough, however, to cause those who sought the amendment of his Act to shift their ground, for the main point of the Bill which Lord Rayleigh has just brought before the House of Lords is still the repeal of the obnoxious 27th clause of the Act of 1882. The aim of Lord Rayleigh's Bill generally, as will be seen by the "memorandum" in another column, is to place the electric light upon an equal footing with gas as far as legislation is concerned; and, whatever may have been necessary three or four years ago, the time has now certainly arrived when electric lighting enterprise should no longer be subjected to severe restrictions, and should be permitted to treat, free and unfettered, for a share of the public patronage. The committee which has for the last twelve months been working at this matter, framing draft clauses for the Amendment Bill, and endeavouring to influence public opinion in favour of the removal of restrictions, is composed of gentlemen well known in connection with electrical matters; they are not all representative merely of company interests, but are just those who are best qualified to judge of the actual requirements of the case. The fruits of their labour are now before us in Lord Rayleigh's Bill, the most remarkable point in connection with which is that it is almost identical in its provisions with the demands of those who first agitated for a change in the law relating to electric lighting undertakings. One or two interesting points strike us as being worthy of notice. If the Bill becomes law, the maximum dividend which undertakers may pay is 10 per cent. per annum; if a larger dividend is earned, provision is made for a reduction in the price charged for the supply of electricity, but for every farthing per electrical unit taken from the price an additional 5s. per hundred pounds may be paid in dividends. Thus a direct incentive will be afforded for the cheapening of the commodity. If the undertaking still earns more than the dividend payable the surplus must be invested in Government securities as a reserve fund, to be used for the equalisation of dividends and for such special purposes as may be required. There is nothing in the Bill which precludes the purchase of an undertaking by a local authority by agreement; indeed, its framers express their opinion that "reasonable facilities" should be given to local authorities for the acquisition of successful undertakings. Taken altogether, the Bill seems to meet the case very fairly, and we hope to see it pass into law.

But now a word upon another side of the question. We have before asserted that the Electric Lighting Act has been made the scapegoat for much bad work and many failures with which it had no real connection. Whatever may be said by chairmen of electrical companies when accounting to their shareholders for the lack of a dividend, it is an indisputable fact that even now it is impossible to enter upon a central station scheme with the certainty of either practical or financial success. While electrical apparatus have been improved during the last few years to a high state of excellence, there is very much left to be desired when the combined use of these apparatus is attempted for public lighting purposes. The one notable experiment in central station lighting with the aid of secondary batteries in this country has ended in failure, to the justification of our repeated predictions. A great deal has yet to be learnt in regard to the practical development of electric lighting, before it can be entered upon and carried out with the same certainty and precision as gas, and we trust those concerned will not relax their efforts to overcome the difficulties in regard to details which have, so far, prevented successful working. Much as the Electric Lighting Act has been abused, we feel convinced that it has been of incalculable benefit to the few companies which remain in existence, by standing in the way of their hastily embarking upon rash enterprises, which could only have led to disaster. But the time for its usefulness in a repressive capacity has passed, and we hope and expect to see it very shortly modified and extended in such a manner as to encourage genuine enterprise.

Electric Communication in the House of Commons.—Mr. Buxton, last week, asked the hon. member for Staffordshire (north-western division) whether he would consider the advisability of establishing electrical or telephonic signals to the library, reading room, and other parts of the House of Commons, whereby members might be informed of the business under discussion, and of the name of the member addressing the House. Mr. Leveson-Gower said the First Commissioner would take the proposal of the hon. member into consideration. It was one, however, of some magnitude.

ELECTRIC LOCOMOTION.

By A. RECKENZAUN.

XIII.

PREVIOUS calculations show that the power absorbed in the propulsion of an electric car without secondary batteries amounted to 3·99 H.P., whereas the same car, when carrying secondary batteries, requires 4·88 H.P. whilst running under precisely similar conditions.

This difference is by no means serious; but there is about one horse-power and a-half per car lost in the battery, which is the difference between the energy given off by the charging dynamo, and that received by the motor on the vehicle. On the other hand, with the conductor system, where the mean resistance of the leads was taken at ·4 ohm, the maximum running current 47·1 ampères, and the current on the level road 13·82 ampères, we find that the loss through heating the conductors varies when running between 3 H.P. and ·1 H.P. per car; nevertheless, this method of propulsion will, theoretically, prove more economical than the accumulator system, provided that *no artificial resistances* are employed for the purposes of regulating the currents and speeds; but then the motors would have to be perfectly self-governing under widely different loads. If we use no idle resistances with the motor, as assumed in Article IX., and if at one moment four cars were starting and eight running simultaneously, there would be 368 ampères needed for that instant, in which case a temporary heat waste of $368^2 \times \cdot 4 = 54169$ watts, or over 73 H.P. would take place in the conductors.

It is the frequent stopping and starting which reduces the efficiency of the electric tramway with conductors; but as this system will find its application in isolated districts where the bulk of the passengers will travel either the whole distance or to given stations, these disadvantages will not be so serious as they appear at first sight.

The accumulator car, again, will find its development and application in towns, taking its turn with the horse cars, which stop as often as the traffic requires it. The total power consumed will, in spite of extra weight and losses in the conversion of energy, compare most favourably with the conductor system, steam, or any other mechanical power.

If it were merely the cost of power, and the usual well-known items of depreciation in the motive power apparatus, then we could at once draw up a general statement of costs of working our tramline. We know pretty well what a steam horse-power costs, and what the maintenance of dynamos and motors ought to be per annum or per car mile, but the accumulator car contains peculiar parts, whose functions we understand, whose market price we know, but whose depreciation is surrounded with much obscurity; in fact, nobody cares to touch this point, whilst few have the remotest idea of the expenses connected with renewals or repairs of secondary batteries.

Considering that these batteries are made of the cheapest metal, next to iron, one may expect that they are cheap in first cost; it is not the first cost, however, which gives us much concern at present, but the depreciation; and we need not even fix such depreciation at so much per cent. on the prime cost. These accumulators have no other ingredients but lead, their receptacles may be of wood, lined with lead, containing dilute sulphuric acid; the lead plates may, in preference to other substances, be kept apart by India rubber insulation.

Strong wood boxes, protected externally by a coating which preserves the wood from the effects of acid moisture, and internally lined with thin but pure sheet lead, ought to last a long time—several years, at any rate. Three square feet of teak wood, half-an-inch thick, suffice for one tramcar box with lid, including waste. Two square feet of sheet lead, weighing together 4 lbs., serve for the lining The boxes, of course, must be substantially made, with excellent joints; but the cost of making them in quantities can be easily ascertained.

What concerns us most is the renewal of plates. The positive plates deteriorate gradually; the conducting grids get oxidised, brittle, and therefore unserviceable in course of time. This disintegration takes place in proportion to the amount of work that has been done by them. It is the positive plates which require renewing first and most often; but the old plates contain as much lead as the new ones, only they contain some sulphate in addition to oxygen, and the part that originally formed a metallic frame is now a brittle mass. These worn out plates, however, are not valueless; the lead has a recognised market price, and such old plates should return at least from 60 to 70 per cent. of new lead when converted. Including terminals, and waste in manufacture, we require about 14 lbs. of lead (metallic and red lead) for the positive plates of a tramcar cell. These positive plates, when carefully used, should last twelve months; but we prefer to renew them before they are quite worn through, and change them systematically, say, every six months.

Including labour and waste, the 14 lbs. of old plates are really only worth 7 lbs. of new lead; we have thus to spend the money for 7 lbs. of lead every six months for each cell, which, at 1½d. per lb., comes to 10½d. One set of cells for a car would thus take £5 5s. worth of lead per annum; and if we used three sets for each car, the expenses for metal in positive plates will amount to £15 15s. in a year. The labour value in making plates out of lead is not so easily fixed, as it depends upon quantities and facilities of manufacture; this item may be less or more than the cost of material, or it may be the same. With a well organised and first-rate system, turning out large quantities, this cost may be equal to the price of the lead, or £15 15s. per annum per car; bringing the item of renewing positive plates up to £31 10s. a year for a two-horse car, running, say, 90 miles per day, and with 300 working days in the year, this would make an addition of ·28d., or a little over a farthing per mile run.

So far we have only referred to the positive plates, and have said nothing about the negatives. They give little trouble, they do not crumble to pieces with overwork, but they also have faults which reduce their lifetime. It is often said that the spongy lead plates are everlasting, or nearly so; but this is not the case, for they also decay. The grids certainly remain intact; but the paste is turned into white sulphate right through, and the plate finally fails through inertness. But such plates should last at least four times as long as the peroxidised electrodes, and therefore cost less than a quarter of these in maintenance per annum. Adding this to the item previously obtained, we have ·35d. per car mile for renewals of plates. If we allow a liberal amount for repairs on boxes, then the whole cost of accumulator renewals may reach ·5d. per mile. Some persons probably may say that the time is not ripe for estimates based on a large-scale-production of lead plates, but such persons must be reminded that, by allowing three sets of cells per car, we have an unnecessarily large reserve, unless the line is very much more difficult than the one we took for our calculation, and we may dismiss this part of our subject in full confidence of having treated it in a liberal spirit.

Were it not for the extreme lightness and the great activity required of these tramcar accumulator plates, then depreciation account could be rendered considerably less, but prolonged experience tends to dictate definite rules, and we are at last in a position to fix reliable items in estimates, showing the cost of electric locomotion where secondary batteries form part of the propelling apparatus.

Charge and Discharge Regulators. — The letter which we have received from Sir Thomas S. Bazley apparently justifies our queries respecting the Elwell-Parker regulator described in our issue of the 5th inst.

SECONDARY BATTERIES AS REGULATORS.

WITH reference to the correspondence now being carried on in our columns on the above, we are glad to be able to place before our readers the results obtained from the shunt dynamo machine to which Mr. Littleton refers. These results are as follows :—

Current.	Difference of potential at brushes.
SPEED 900 REVS.	
0 amps.	208·0 volts.
30 ,,	198·0 ,,
46 ,,	192·0 ,,
64 ,,	186·0 ,,
72 ,,	182·0 ,,
SPEED 800 REVS.	
0 ,,	173·0 ,,
26 ,,	164·5 ,,
38 ,,	170·0 ,,
50 ,,	155·0 ,,
66 ,,	146·0 ,,
74 ,,	140·0 ,,
SPEED 600 REVS.	
0 ,,	121·6 ,,
16 ,,	117·5 ,,
28 ,,	113·2 ,,
38 ,,	110·0 ,,
54 ,,	101·0 ,,
62 ,,	96·5 ,,

The resistance of the armature is ·119$^{\omega}$· and the field-magnets 58·9$^{\omega}$· It will be observed that the difference of potential falls considerably as the current increases, and this the makers declare to be the proper condition of things required for charging accumulators when the power is supplied by a gas engine or by any prime mover where the delivery of power is in the nature of emphasised intermittent pulsations. We ought to mention that the drop in potential in actual working is somewhat greater than above indicated due to a permanent resistance being placed in the shunt circuit, the dynamo having been built of larger size than was actually necessary for Mr. Littleton's requirements.

From a graphic representation of the relation between the characteristic of the dynamo, the E.M.F. of the cells and the resistance in circuit, it can be shown that with a dynamo in which the curve rapidly descends, the variation in E.M.F. at the terminals of the accumulators for a given variation in speed is much less than with a dynamo in which the curve is straighter and which gives, therefore, a more constant potential. It is also shown that the variation in E.M.F. decreases with a diminished resistance of cells, and finally, if the resistance of the cells and leads is 0, the dynamo can be driven with any variation of speed without affecting in any way the potential at the accumulator terminals.

We wish this question to be discussed on its scientific merits alone, and we must therefore ask those who may favour us with their views on the question to argue close to the matter in hand. Obviously we are not helped to a solution by the statement that "accumulators are by far the most efficient and reliable form of regulator," for admitting this, the object in view is to discover the source of the imperfection which *does* exist, and that they do not act perfectly under all conditions even those most interested must admit if they fairly face the problem.

We do not quite follow Sir David Salomons in his remarks regarding the electrical perfection of dynamos. All good makers construct their machines with the exact conditions of working kept in mind, and the best machine electrically is the one which best fulfils the requirements of the user when working under the conditions for which it has been intended. There is no such thing as electrical perfection *per se*. In this, as in all departments of applied science, the apparatus must be constructed in accordance with the end in view, and perfection is to be gauged by the accuracy with which the adjustment of means to ends is made.

We fear we are among those who would call Sir David to task for stating that a fall in the speed of the dynamo causes a rise of the E.M.F., but we shall be glad to modify our opinion when it is proved to our satisfaction that this is really the case. Meanwhile as neither of our correspondents seem to have satisfactorily answered the question first put, we trust those who can throw further light on the subject will favour us with their views.

THE CHARACTERISTICS OF ALTERNATING CURRENT DYNAMOS.

IN an article which appeared in the ELECTRICAL REVIEW for April 12th, 1884,* some comments were made on the particular forms of characteristic given by separately excited dynamos for generating continuous currents, and it was shown that the curves obtained from these machines exhibited a certain fall of potential due to the weakening effect on the magnets, of the currents flowing round the armature core. Curves were plotted in which ordinates were made to represent the difference of potential at the brushes, and abscissæ the currents flowing in the armature, and from these it was observed that the line connecting the difference of potential with the current had a very different curvature as the magnets were excited to a greater or less degree. When the magnets were saturated the line was approximately straight for a considerable distance, and had only a small inclination towards the horizontal. As the magnets were weakened the inclination increased and the curvature became more decided until, finally, with a still further diminished magnetic intensity the line curved over rapidly at a greater inclination. A formula which approximately expressed the difference of potential at the brushes when the magnets were strongly excited was given of the form

$$\text{V} = \text{E}_1 - \text{C}\,(q + r + p)$$

where V is the difference of potential at the brushes; E_1 the E.M.F. when running on open circuit; C, the current flowing through the armature; q, a term which measures the weakening effect of the armature on the fields; r, the resistance of the armature; and p, the spurious resistance due to self-induction. If the formula is to be true, q must be very small, and this is the case only when the magnetic effect due to the magnets is very large compared with that due to the armature. Under these circumstances q may be neglected altogether, the formula becoming simply

$$\text{V} = \text{E}_1 - \text{C}\,(r + p).$$

When q becomes appreciable it can scarcely be called a constant, but is rather a coefficient, which has a different value for every different value of the current.

The analogy between the curves from separately excited continuous current and alternating current machines is a close one, and it will be seen from fig. 1 that under different degrees of magnet excitation the curves obtained from the latter have very different shapes.

In a note from the pen of M. Felix Lucas, published in the REVIEW under date before referred to, a formula for the E.M.F. of alternating current machines is given of the form

$$(\text{R} + r + p)\,\text{I} = \phi$$

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* The E.M.F. of Dynamo Machines excited by a Constant Current.

whence we get

$$\text{R I} = \phi - \text{I}\,(r + p)$$

where ϕ is the E.M.F., I the current, R and r the resistances of the external part of the circuit and the armature respectively, and p a fictitious resistance due to self-induction. The latter formula is identical with the formula given for the difference of potential at the brushes of separately excited continuous current machines, but in experimenting with alternating machines I have not found the relation between the difference of potential and the current to be of the simple character here given unless the field magnets are very strongly excited and the convolutions on the armature few in number. This was the case with continuous currents. When the field was strong the characteristic was practically straight, but as the field was weakened the characteristic drooped with a curvature increasing as the magnetism decreased. M. Lucas assumes that ϕ is constant for all values of the current, but as a matter of fact this is not the case, since the strength of the fields is reduced by the increased current in the armature. The weakening effect becomes of importance, especially when the fields are weakly excited, and this is fully shown by the curves here drawn which were obtained from a W_2 Siemens alternating current machine driven at a constant speed of 650 revolutions per minute. The current in ampères represented by abscissæ was measured by a Siemens dynamometer, and the ordinates show differences of potential at the brushes as measured by a Cardew voltmeter. The machine had on its armature 12 coils, each having 208 convolutions of wire. The coils were for the test coupled in six parallels of two in series and had a resistance of ·112 ohm. There were 12 magnets on each side of the armature having cores $2\frac{1}{16}$ inches diameter with 185 turns of wire on each. Distance between the magnet faces about $2\frac{1}{4}$ inches. The magnets were coupled in series, and when thus coupled they are in usual working excited with a current of 21 ampères, the machine then yielding about 75 ampères. The following are the results obtained:—

SIEMENS W_2 MACHINE.—Speed 650 Revs.

TABLE I.

Magnets excited with 24 ampères.

Current.	Difference of potential at brushes.
0 amps.	125·00 volts.
20·65 ,,	123·32 ,,
26·67 ,,	120·00 ,,
29·21 ,,	121·00 ,, (?)
33·74 ,,	118·92 ,,
39·00 ,,	117·00 ,,
43·00 ,,	116·00 ,,
50·60 ,,	111·13 ,,
54·67 ,,	110·20 ,,
63·11 ,,	108·82 ,,
68·52 ,,	106·46 ,,
71·57 ,,	102·87 ,,
73·53 ,,	100·47 ,,

TABLE II.

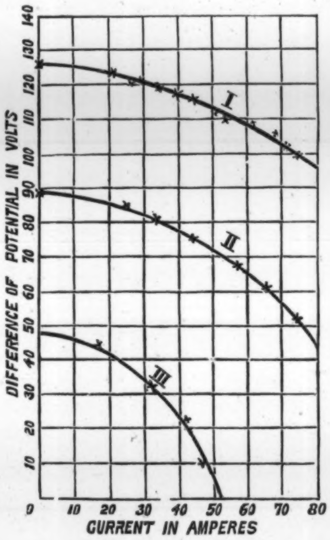
Magnets excited with 12 ampères.

Current.	Difference of potential at brushes.
0 amps.	89·00 volts.
16·87 ,,	86·55 ,,
23·85 ,,	85·24 ,,
33·74 ,,	81·31 ,,
44·63 ,,	75·81 ,,
58·43 ,,	68·43 ,,
65·33 ,,	61·00 ,,
72·56 ,,	52·00 ,,
80·00 ,,	45·00 ,,

TABLE III.

Magnets excited with 6 ampères.

Current.	Difference of potential at brushes.
0 amps.	47·00 volts.
16·87 ,,	43·75 ,,
23·85 ,,	39·5 ,,
33·74 ,,	32·00 ,,
41·32 ,,	23·13 ,,
47·71 ,,	10·00 ,,
51·30 ,,	0 (short circuit)



Curves I., II. and III. corresponding to the three different sets of readings have been plotted from these results, and it will be observed that the curvature becomes excessive where the magnets are weak, as in III., the line here cutting the axis of abscissæ at 51·30 ampères. A greater current than this with the same speed and exciting current is impossible, and this explains why alternating current machines can be in some cases short circuited with impunity.

I have not been able to try the effect of introducing into the armature coils iron cores, but it may be safely inferred that if other conditions remain the same the E.M.F. will fall more rapidly with than without these cores, although the initial E.M.F. will be greater. It is also probable that the curve may be of a different character, the E.M.F., for example, decreasing rapidly at the beginning of the curve, then more slowly and finally with rapidity. This is mere surmise, and it would be well if some experimenter, with time at his disposal, would undertake the experiment indicated for the benefit of his less fortunate brethren.

W. B. ESSON.

HOW TO WIND MAGNETS FOR SHUNT, SERIES AND COMPOUND MACHINES.

II.—SHUNT MACHINES.

LET it be required to wind the magnets so as to make a shunt machine.

It is evident that the armature has to supply the sum of the currents in the external circuit and in the shunt magnets. It is therefore necessary to determine about what this shunt circuit current should be. In large machines it may be taken at about 1·5 to 2·5 per cent. of the current in the external circuit, and in small machines for from 10 to 20 incandescent lamps, it will have to be taken as high as 10 per cent., and even higher, in order not to make the cost of the wire too great. Having determined this, approximately only, the machine is run as above described until it gives the required current for the lamps plus that which will be required by the shunt. Let (a W) represent the magnetism in ampère windings obtained in the test under these conditions.

It is evident that the size of the wire to be used for the magnets depends upon various quantities and conditions. For instance, it must not be too small, so that the current does not heat it too much. It must be large enough, so that the total resistance of the coils is not so great that it will not take its proper current as shunt to the machine. It must not be so large, that it takes up more space than is allowed for the coils. It must not be so small, that after heating, its resistance becomes too high to take its proper current. It must be so large that its resistance is small enough to enable an adjustable resistance to be placed in series with it, and to regulate the machine for varying service. Therefore, in trying to calculate the proper diameter directly from the ampère windings, by trying different values for the current and corresponding number of ampère windings and calculating the resistance and size of the coils for each case, to see which wire is correct, it may be found to be a tedious process and one which may or may not be of considerable length.

In order to take into consideration all these factors, the writer has deduced the following formulæ, which may be used to determine, by a single calculation and with certainty, what diameter will meet these conditions, thereby facilitating calculations very much, as it eliminates the element of guessing.

Let (a W) represent the ampère windings obtained from the above experiment.

a = current in the shunt magnets of the finished machine.

W = total number of windings or turns on all the magnets of the finished machine.

R = total resistance of the magnet coils of the finished machine, in legal ohms.

V = potential at the poles of the finished machine.

d = diameter of the naked wire in mils.

l_m = mean length, in inches, of one winding.

l = length, in inches, of one winding of the lowest layer, which is about the same as the periphery of the core.

Then it is evident that the resistance is proportional to the total length, W l_m, and inversely as the square of the diameter, and is equal to

$$\mathrm{R} = 50{\cdot}13 \, \frac{\mathrm{W} \, l_m}{d^2} \, \theta$$

in which θ is the specific resistance, that is, the resistance in legal ohms of 1 metre of copper wire of 1 square millimetre cross section, at 0° C., while the constant 50·13 contains all the various reduction constants.

But by Ohm's law

$$\mathrm{R} = \frac{\mathrm{V}}{a}.$$

Therefore

$$\frac{\mathrm{V}}{a} = 50{\cdot}13 \, \frac{\mathrm{W} \, l_m \, \theta}{d^2}$$

From which

$$d = \sqrt{50{\cdot}13 \, \frac{(a \, \mathrm{W}) \, l_m \, \theta}{\mathrm{V}}}$$

From which it is evident that the diameter can be calculated directly from the (a W) and the potential, if the mean length of one winding is known.

The value of this mean length can be determined from the inside length, l, if the thickness of the coil is known. But this thickness again depends on the number of ampère windings, the resistance of the wire, and the thickness of the insulation. It is possible to determine relations between all these and introduce them into this formula, thereby eliminating the unknown factor l_m, but the writer has found it to make the formula so complicated that it becomes practically too troublesome to use.

In actual practice so many elements enter, which are either inexact or limited to certain values, that an exact calculation has little value. For instance, the copper may have, and probably has, a different specific resistance than any figure which one might assume. Again, an almost inappreciable diminution or increase of the diameter changes the resistance materially; so also the temperature to which it is raised. The sizes of wire are also limited to certain fixed numbers, and the insulation has not always the same thickness. For these reasons, therefore, the following approximate method of using this formula will be found to be practically safe and correct, while it is at the same time much more simple.

The thickness of the coil is practically limited; if it is too thin, there is more iron in the core than is necessary, or the magnets are too long, or both; if too thick, the magnets are probably over saturated or too short, or both. Some of the older authorities say that the thickness of the coil and core can be made equal. In the writer's experience, however, it was found that this is far too thick for machine magnets, as it makes the cost of both wire and energy much greater than it ought to be. A better figure, obtained by the writer from actual practice, is, for a flat oval magnet, a maximum limit of about one-third the thickness of the core for cast iron, or about one-half the diameter of the core if it is circular. This will be found to be more nearly correct in actual practice for machine magnets, as it is based on real results as distinguished from theoretical deductions.

The thickness being, therefore, limited to a comparatively small range, it is quite safe to calculate the mean length of a winding from some assumed thickness of coil, for it will be found that this length will vary very little for any possible variation in the thickness. For instance, in an actual case of an oval magnet, diminishing the thickness of the coil as much as 50 per cent. decreased the mean length only 7 per cent.

Assuming, therefore, a certain approximate thickness of coil and having given the periphery of the core, the mean length may readily be calculated as follows. For an oval magnet, not too flat, the lengths of the inside and outside layers are in the proportion:

$$\frac{a + b}{a + b + 4\,c}$$

in which a and b are the length and breadth of the oval cross section of the core, and c the assumed thickness of the coil.

This gives for the mean length of a winding

$$l_m = l + \frac{2\,c\,l}{a + b}$$

l being the periphery of the core in inches. For a circular magnet in which the core has a diameter D the mean length is, evidently,

$$l_m = \pi \, (\mathrm{D} + c).$$

If it is found, after completing the experiments and calculations, that the assumed thickness of the coil is much too small, then it is preferable to lengthen the magnet cores so as to reduce this thickness of coil, provided the magnet cores are not already saturated, that is, the cross section of the core is not too small.

On the other hand, if it is found that the necessary thickness of coil is much smaller than the assumed, it shows that the magnets are too long.

Having now determined this mean length for an assumed thickness of coil, the diameter of the wire can be calculated directly from the formula:

$$d = \sqrt{50{\cdot}13 \, \frac{(a \, \mathrm{W}) \, l_m \, \theta}{\mathrm{V}}}$$

without having first to determine what current and what number of windings to take, as the known quantity (a W) enters directly into the formula.

From what has been said above, some allowance, or factor of safety, must be taken for the resistance, in order that when the wire is wrapped, it is not found that the resistance is a little too high to take its proper current. An allowance should also be made for introducing an adjustable resistance by which the machine may be regulated. The factor of self-induction may also enter, and will have the effect of apparently increasing the resistance, depending upon the degree of pulsation of the current, or, what is the same thing, on the number of commutator strips. In order to make allowances for all these factors, and introduce them into the formula, it is only necessary to diminish the value of the potential, V, in the formula accordingly. For ordinary purposes, 10 to 15 per cent. may be allowed, but it is safer to take 20 per cent., and even 25 per cent., if considerable variation in the adjustable resistance is to be allowed for. Assuming 20 per cent., it is only necessary to multiply the potential, V, by 80, and introduce this factor directly into the formula.

Assuming for ordinary good copper wire a specific resistance θ equal to 0·0162 at 0° C., the formula becomes, assuming a temperature of about 70° Fahr.,

$$d = \sqrt{\cdot 875 \frac{(a\ \text{W})\ l_m}{\text{V}}}$$

in which d is in mils. and l_m in inches.

If this should give a value which is too small, so as to be impractical, it shows either that the length, l_m, is too small, that is, the cross section of the magnet too small, or that the ampère windings are very small, or that the potential is high for the required ampère windings. In the last two cases it is only necessary to take a larger diameter of wire and add external resistance in the shunt circuit.

If the formula should give a very large diameter, it shows that either the magnets or the ampère windings are too large, or that the potential is very small for the required ampère windings. If the magnets are already saturated, and therefore cannot be made smaller, then it shows that the machine is overworked, unless it happens to be a low potential and high current machine, such as a plating machine, in which case a large value for d is quite correct.

Having determined d, it is evident that if we could now assume any current, a, and make the corresponding number of ampère windings $\frac{(a\ \text{W})}{a}$, in all cases we would obtain the proper ampère windings and the proper resistance. But there are practical limits, which are quite narrow in most cases, for we have assumed a certain mean length, l_m, or a thickness, c, of the coil, and we must limit ourselves to this value of l_m to a certain extent at least, in order that the resistance may not differ much from what we must have. The method to pursue, therefore, is as follows: assume a certain current, a, for a large machine about 1·5 to 2·5 per cent., and for a small machine as high as 10 per cent. of the total current, and by dividing it into the ampère windings, to obtain the number of turns, calculate the space occupied by the coil (remembering to use the outside diameter of the insulated wire), and see how near the thickness corresponds to the assumed thickness, c. If it turns out to be much thicker, it shows that the machine is overworked, and you have to take a larger current in order to diminish the number of windings. If, on the other hand, it gives too small a thickness of coil, it shows that the machine could be run more economically if necessary, and a smaller current could be used at the expense of an increased cost of the wire. It would not require more than a few trials to determine the right number of turns.

If it is found that with the proper assumed current and the corresponding windings, it makes this thickness of coil too great, it shows that the magnet cores are too short, provided they are not already saturated. Or if, on the other hand, the thickness of the coil is found to be much thinner than the assumed, it shows that the magnets may advantageously be shortened, provided they are not already saturated.

ELECTRIC LIGHT AT THE PRINCE'S THEATRE.

By ERNEST L. BERRY.

THIS installation has now completed its second year of running without a break down or any mishap in the lighting. The plant consists of a 12 H.P. Clarke's gas engine, manufactured by L. Sterne and Co., a Siemens L.D$_1$. dynamo, and storage cells by the Electrical Power Storage Co. The Swan lamps require 108 volts E.M.F., and are of 16 C.P.

For further particulars of the installation refer to ELECTRICAL REVIEW of April 11th, 1885.

The engine has during the year run for 2,559 hours, and has not given the slightest trouble either in starting or when at work. It was overhauled in December last, and the water jacket cleared of its deposit of lime. The only renewals we have had for the engine have been a few piston rings.

Besides doing its ordinary work of driving the dynamo, it is used frequently for pumping water into the tanks to supply the hydraulic fire proof curtain and lift. In regard to the E.P.S. cells, as a difficulty was experienced in the leaking of the teak boxes, it was decided, while making a change, to put in some of the new cells containing all the latest improvements and supplied in glass boxes, and of these new cells, although put to very severe tests, not one has failed.

We have repacked several of the teak boxes with new positive plates and lead connections, and these have answered admirably. We had, up to 16th January of this year, one cell of the old type, which has been in constant work for two years, and has not on any occasion failed; it has not been repaired or seen to in any way. It is evident, therefore, that there is no reason why, when carefully made, the accumulators should not last throughout this length of time without being in any way renewed, and it is expected that this result will be obtained with the later cells put down. The dynamo has run very well; a new commutator was put on in December last, the old one during its run having been turned up three times, and 10 pairs of brushes have been used during the twelve months. The lamps show a somewhat better average than last year, on account of our being able to get 30 of the broken looped ones repaired. We have renewed during the year 78 lamps from the following causes:—38 by carbons, 10 by accident, and 30 by loops breaking off; the cause of so many loops being broken off is through using 18 lamps to light up a scene of the "Great Pink Pearl" for six months, the constant moving about breaking the loops, and occasionally one got broken by a fall. There are several lamps that were originally put up still burning, having run for 2,500 hours. Subjoined is an abbreviated account of the working expenses, and also the repairs and renewals for the year.

Working Expenses.

	£	s.	d.
Electrician and assistant ...	239	5	6
Gas	188	4	0
Lamps	14	5	0
Oil for engine, shafting, dynamo and pump	10	0	0
Waste	1	12	6
Ten pairs brushes	2	10	0
Lamp shades	0	15	0
Sundries, &c.	4	0	0
	£460	12	0

Repairs and Renewals.

	£	s.	d.
Dynamo	12	9	0
Engine	7	0	0
Accumulators	187	9	6
Belts	11	5	4
	£218	3	10

	£	s.	d.
Total for working	460	12	0
„ repairs	218	3	10
	678	15	10
„ previous year	452	10	0
	£1,131	5	10

grand total for two years' working.

The increase in the second year's expenses are entirely due to extra performances.

Subjoined is Mr. Bruce's certificate as to the working of the installation :—

"I have great pleasure in again certifying to the successful working of the electric lighting at the Prince's Theatre. It has been in operation for more than two years, and during the whole of that period it has not failed on any one occasion. I am also greatly pleased at its adaptability for stage purposes ; the lighting of the stage during one act of the 'Great Pink Pearl' was most successful and original, and I hope before long to still further try its uses for stage effects.

"Edgar Bruce.

"The Prince's Theatre,
"*March 11th*, 1886."

THE ELECTRIC TRAMWAY AT RYDE.

The formal opening of the new electric tramway which has been laid on Ryde Pier by the firm of Messrs. Siemens Brothers, a description of which has already appeared in the Electrical Review, took place last week in the presence of the South-West of England District Association of Gas Managers, who this year held their annual dinner at Ryde. The working of the electric tramway was explained by Mr. A. Siemens to the visitors, who numbered about 70. The latter were then conveyed in two parties up and down the pier, two cars being used, and the smooth and rapid motion gave the highest satisfaction. The President of the Association afterwards gave a banquet at the Pier Hotel. In the course of the *post prandial* proceedings he proposed the health of Mr. Siemens in terms of a highly eulogistic character. Mr. Siemens, he said, was the representative of a noble scientific family, and his reputation was world wide. He had done great things with electricity as applied to railways in Paris, Ireland, and on different parts of the Continent, and now, for the first time, England had an opportunity of seeing what might be done for locomotive travelling by means of electricity.

Mr. Siemens, in responding, remarked that that day they were in some respect celebrating the triumph of the application of electricity as a means of propulsion. Every scientific discovery or development of knowledge was for the general good ; and just as gas had not extinguished our lamps, or the steam locomotive horse traction, just as little would the electric light extinguish gas. The family to which he had the honour to belong had studied for the purpose of developing all branches of science and useful invention. Metallurgy, glass making, gas making had been some of the subjects to which they had devoted attention, and now electricity. The general progress of the race was what they all ought to aim at.

Alderman Cudlipp, in introducing "Prosperity to the town of Ryde" remarked that he believed it would mark a new era not only for the Ryde Pier Company but also for the inhabitants of the town and the Isle of Wight generally.

Apparatus for High Electromotive Force.—The Board of Examiners of the Franklin Institute give a report in this month's journal of the society on "Apparatus for high electromotive force." This will be found of much interest to electrical instrument makers.

THE EFFICIENCY OF DYNAMOS.

Dr. Hopkinson writes that in Mr. Gisbert Kapp's article, which we reproduced from a recent issue of the *Engineer*, on the experiments to determine the efficiency of the Edison-Hopkinson dynamo recently undertaken by Messrs. Mather and Platt, there is an error in the data which is important, as it materially affects the results deduced from the figures. Dr. Hopkinson says : Mr. Kapp has assumed that the zero of the dynamometer scale employed was the point at which the index would stand when the machine was at rest. Such, however, was not the case, as the scale was placed arbitrarily, and all the experiments made by taking the difference of two readings—the one when the machines were working with a known load and at a known speed, and the other when the machines were running at the same speed without load and with the magnets unexcited. The dynamometer readings, therefore, in the three sets of experiments quoted by Mr. Kapp were 29, 27·5, and 23 respectively, and the efficiency in the case selected by Mr. Kapp for discussion is—efficiency of generator, 93·23 ; efficiency of motor, 93·37 ; of the double conversion, 87·05.

It is true, as Mr. Kapp points out, that this does not include the friction of the bearings and of bending the belt round the driving pulley. This was intentionally excluded as being essentially a variable quantity depending on lubrication and the kind of belt employed, but at the same time it was determined accurately for the two machines in question by the following device :—The dynamos were run at their proper speed without load, and the dynamometer reading noted, the driving engine was then reversed, and the dynamometer again read ; clearly the difference in readings is twice the friction of the two machines plus twice the work done in bending the belt. By this method these losses for one machine were found to amount to 628 watts = 0·84 horse-power when running at 800 revolutions. This is materially different from Mr. Kapp's calculation of 5·18 horse-power for the two machines.

Again, Mr. Kapp desires to take into account also the variation in the friction, if the belt were transmitting the full power required to drive one dynamo. Here, again, in any comparative results, this would be better omitted, as it depends entirely on the angle which the belt makes with the horizontal, and under certain circumstances the friction might be actually less when the larger power was being transmitted. Following, however, Mr. Kapp's suggestion that the mean of the results with and without friction should be taken, there is a loss of 314 watts not taken account of in Messrs. Mather and Platt's figures, amounting to 0·73 per cent. Hence the commercial efficiency of the generator is 92·5 per cent., and of the motor 92·6 per cent., as against 91·5 per cent. and 88·5 per cent., the figures calculated by Mr. Kapp.

It would, perhaps, have been unnecessary to have entered into the above discussion in regard to a difference so small, but in the case of dynamos so perfect as converters of energy that the total loss is under 8 per cent., a matter of 1 per cent. is no small proportion of the whole waste.

REVIEWS.

Formulaire Pratique de L'Electricien. Par E. Hospitalier. Quatrième Année, 1886. Paris : G. Masson, Editeur, 120, Boulevard, St. Germain.

In issuing the new edition of his well-known work, M. Hospitalier has made numerous corrections and changes such as practical experience has suggested. He has not hesitated to substitute correct terms for erroneous ones, in cases where the latter, through long continued use, have become almost established. The whole of the phenomena of induction have been considered as due to variations in the flow of magnetic force surrounded by a circuit. The chapter on "Measurement" has been made more complete by the addition of the methods of measurement of periodic currents, either alternating or direct, and descriptions are given of new forms of galvanometers, wattmeters, &c. Statistics are also furnished relative to new batteries, thermo-piles, accumulators, incandescence lamps, motors, &c. Reference is made, moreover, to "transformers." Altogether, the new edition is a marked advance on the old, and has greatly improved the original work, excellent as the latter was.

Precautions to be Adopted on Introducing the Electric Light, with Notes on the Prevention of Fire Risks. By KILLINGWORTH HEDGES. London: E. & F. N. Spon, 125, Strand.

There is much in this small work that is commendable, and if it were not that it to too great an extent partakes of the nature of an advertising catalogue, it would be deserving of a more highly favourable notice than can under the conditions be given it. The rules and directions for running wires for selecting the sizes of the latter, for fixing "cut-outs," &c., are very plainly put. An example of a Specification for Electric Light Work is also most useful. The few formulæ and tables which are given are, we consider, judiciously selected.

THE AMERICAN NATIONAL ELECTRIC LIGHT ASSOCIATION.

THE RELATIONS OF ELECTRIC LIGHT COMPANIES TO INSURANCE.

By Mr. C. J. H. WOODBURY.

ONE of the elements naturally disregarded at the outset in the rush to invent, make, and install the apparatus, was the possibility that electricity might, like other methods of lighting, become a cause of fire.

Soon numerous fires served as a reminder that electricity as applied at that time, possessed no immunity from consequences similar to those resulting from other methods of illumination, and public opinion for a time had a tendency to veer to an extreme position; even farther from the truth than its first assumption that electricity could not produce a fire.

A careful examination of the circumstances attending a number of these fires, and a repetition of these conditions upon electric lighting plants, served as the basis of the regulations for the use of electric lighting apparatus, prepared by the writer for the Factory Mutual Insurance Companies, a little more than four years ago. It would have been impossible for the work to have been carried on had I not received the most cordial co-operation from the electric light companies; and the electricians at the head of these companies freely gave of their experience, in the endeavour to determine the facts at issue.

The results of this work warranted the opinion that a well-arranged electric lighting plant was the safest method of illumination, and the experience of time has sustained that position.

The essentials for safety in an electric lighting plant are few and simple. In the presence of combustible material, arc lights should be enclosed in globes resting on closed stands with a raised edge, confining the sparks and copper, and some extra stop at the bottom of the lamp to prevent the lower carbon from falling in any contingency. The feeding apparatus at the lamp should prevent the formation of an undue arc in case of any disarrangement. Switches should be constructed so that an arc could not be formed by their use. The electricity must be confined to its metallic circuits, and the conditions of its use controlled.

The regulations found necessary to specify these particulars in detail are of some length, but do not embody any other features. Experience has shown that they have served the purpose for which they were intended, for I do not know of any fire from electric lighting apparatus except where they have been violated.

The chief elements of danger are conductors of high resistance, generally formed by two earth contacts, and sometimes by a conductor between two wires of different potential. Such diversions of current are generally caused by water penetrating the insulation, and it is of importance that the insulation be waterproof, wherever there is liability of exposure to moisture.

Careful attention should be given to the importance of daily tests for ground connections; and for this purpose an ordinary bell magneto is the most convenient apparatus. The electric bells and small galvanometers with low resistance coils frequently used for this purpose, are not sufficiently delicate, as they cannot indicate a weakness in the insulation, unless its resistance be less than ten to one hundred ohms, according to circumstances.

The value of this method of inspection which I have described is shown by the results following its adoption. In the autumn of 1881 and winter of 1882, 23 fires were caused by 61 electric lighting plants in mills insured by the Factory Mutual Insurance Companies in the eastern portion of the United States. The apparatus was inspected and the alterations necessary for safety specified and carried into effect, and there has not been a single fire from electric lighting apparatus on this property since that time, although the number of mills using electric light has increased to nearly 200, and the average size of the plants greatly enlarged. From being a legitimate cause of apprehension on the part of the underwriters, the hazard of electric lighting, in this field at least, has subsided into a matter of routine inspection.

There is a prospect of new matter at issue, which will tend to reverse the present conditions relative to safety in connection with the distribution of electric lighting. There is a widespread feeling of opposition to aerial electric wires, and several city governments with the intrepidity of practical politicians have passed ordinances decreeing that the wires must be buried.

It is well known that the use of all underground electrical conductors is attended with special difficulties.

The few instances where wires over buildings interfered with ladders of the fire department might have been avoidable by the further elevation of the wires, or by their crossing the streets at nearly right angles. In the natural course of improvement the lines in cities are being changed from their scattered courses and systematised upon permanent fixtures high enough to carry the wires a reasonable distance above all roofs. Aerial wires certainly furnish the most ready means for electric companies to reach their customers, who are frequently distributed very unevenly over a city, and, like all other seekers after trade, may at times conflict with other interests.

The network of wires over cities serves as the most efficient protection against lightning—these conductors, by their great number, scattering the force of thunderbolts and conducting them to earth; on this account thunderstorms are much more destructive in the country than in cities.

As for personal danger, a lineman is in infinitely greater danger from gravity than from electricity.

I repeat that most of the fires from arc lighting systems have resulted in the diversion of the current by two contacts, one of them being a ground which had existed for an unknown time and the second being an accidental ground, generally of increasing resistance, until it converted the electricity into heat whose temperature was high enough to ignite combustible material. When a ground exists anywhere on a circuit, this ground is trying to form a second connection at the weakest point in the insulation anywhere on the whole circuit, irrespective of position. The one connection to earth may exist near the dynamo and the other in some building at the extreme portion of the circuit, or it may be only a few inches away.

Many underground arc lighting circuits have received faithful trials without obtaining satisfactory results which would warrant their adoption by any form of American practice.

In Philadelphia, the escapes from an underground system of electric arc light wires on Chestnut Street are believed to have been the cause of several severe explosions of illuminating gas leaking through the ground. On Delaware Avenue, in the same city, an underground circuit with different insulation received a careful trial, until the escapes through defective insulation, in spite of numerous repairs, diverted so much of the electricity from the circuit that the lights could not be maintained and aerial wires were substituted. The temperature of these escapes was so great that the sand was partially fused in places, and if the lights had been inside of buildings there would have been a liability of such points of excessive heat occurring in the presence of combustible material with destructive consequences.

The result of a few weeks' experience with a short underground circuit is no measure of its capacity to fulfil the requirements necessary for central station arc lighting, as it requires time to develop the faults in such conductors.

In conclusion, it may be said:—

1. That the present application of electricity forms a relatively safe method of lighting.

2. Underground wires connecting lighting currents contain elements of serious danger in proportion to their defects of insulation.

3. The compulsory burial of all electric wires would be oppressive to the electric interests.

Our methods of life are so closely interwoven with the uses of electricity that we are dependent upon its applications, especially to transmission of speech, telegraphy and illumination, and any interference with the legitimate exercise of those interests will not be measured by the impaired value of plant or load of excessive expenditures, but will be a detriment to each member of the community now benefited by its use.

Mr. W. S. WILKINSON and Gen. JAMES M. ANDERSON, underwriters, of Baltimore, expressed their satisfaction with what Mr. Woodbury had said on the subject of safety. Gen. Anderson said that as far as the Baltimore underwriters are concerned they are completely in the hands of the electric light men so far as such lights are concerned, since there is no official inspection made there as in other cities. There had been comparatively few fires there from electricity, and he regarded it as quite as safe, if not safer, than gas lights. The electric light was used on the Bay Line steamers, and it had given more satisfaction than gas.

Mr. **Gilbert** then called the attention of the Association to the circular recently issued by himself and Mr. English advocating the formation of a mutual fire insurance company among electric lighting companies so as to secure much lower rates of insurance. He said that returns already in from 31 cities or plants showed a total of property liable to destruction in case of fire of $1,171,000, covered by $481,000 insurance, the premiums paid averaging from ¾ per cent. up to 4 per cent., with a total of premium paid for three years of $119,112 on a total loss amounting to about $1,000; that was seven-tenths of a mill on the amount insured. Yet the property was often rated as extra hazardous. He believed there would be in the United States now to insure about $5,000,000, and in five years' time the amount would be trebled. Another argument he presented was that it would help sub companies to secure repairs from parent companies at a price nearer the actual cost, or else would help them "fit up a hospital for their own work."

Mr. **Cleveland** supported the movement warmly, as highly proper and desirable, and offered a resolution endorsing the plan in the name of the association.

Mr. **Morrison** objected very strenuously to any action of the kind.

Mr. **Linnell** instanced Richmond where his company was refused insurance by six companies, and to-day they were insured at the high rate of 1½ per cent. He was in favour of the plan proposed.

Mr. **Woodbury** described the well-known and favourable experience of the New England manufacturers' mutuals, but it seemed to him that the functions of the meeting were merely advisory, perhaps commendatory in such a matter. Whatever was done must be done by the individual action of some of them.

Mr. **Renshaw** complained of the difficulty in getting reasonable insurance on their station in Washington, and approved the scheme of organisation.

Mr. **King** was in favour. They were paying 1¾ per cent. in Minneapolis, and would like to reduce it if possible.

Mr. **Gilbert** said that the average rate of the 31 reports was 1·65 per cent. He held that the lowering of the rate of insurance meant that they would be able to furnish light cheaper.

Mr. **Weeks** said that they had paid 3·10 in Kansas City, but as it was not a living rate, had kicked and got it down to 1·45.

After further discussion, the following was agreed to:—

Resolved, "That this association indorse the plan of an organisation of a mutual electric light insurance company."

LECTURE—ELECTRIC LOCOMOTION.

A LECTURE on Electric Locomotion was given by Mr. A. Reckenzaun on the 10th inst., before the East of London Association of Marine Engineers and Foremen, during an ordinary meeting at the Poplar Town Hall.

Assisted by working models and numerous diagrams, the lecturer explained in his usual clear and lucid manner the principles involved in the production and transmission of electric currents.

After referring to numerous successful electric railways in this and other countries, and describing the various methods of conveying the energy, special reference was made to the mechanical details of construction, and Mr. Reckenzaun dwelt at length upon the necessity for all mechanical engineers to get a thorough knowledge of electrical science; for, he said, electrical engineering was rapidly becoming an important branch of mechanical engineering, and it was in the judicious combination of the experiences of both that electricity has made such rapid advances, and that it will continue to advance. Mechanical engineers are apt to look upon electric locomotion as an expensive amusement; they are apt to declaim against the process of converting steam power into electric energy, and then to transform this energy again into mechanical power, thereby wasting a large percentage of the available force in the course of this double, and often treble, conversion.

Mr. Reckenzaun went to the root of this matter, commencing with the efficiency of the dynamo; tracing the possible losses in conductors, motors, and gearing of an electric tramcar, he showed conclusively that in many instances it is far more economical to convert steam into electricity and use it for propulsion, than to apply steam direct on the locomotive. The doing away with a separate locomotive, which for obvious reasons must be at least as heavy as the vehicle behind it, does in itself offer advantages which more than counterbalance the waste of energy referred to. By placing the electric motor under the vehicle carrying the passengers, we utilise the dead weight of the former and the live weight of the latter, to produce the desired adhesion between the wheels and the rails; this, in the case of a car whose motor receives its energy from conductors, the motive power apparatus need not weigh above half a ton, or taking the system of accumulators, with its extra ton of cells, we see the gain over a steam locomotive, or any other locomotive, weighing from 6 to 10 tons. Considering that the tractive force must be proportional to the load to be moved, it is evident that with so great a saving in dead weight we can easily afford to lose a large portion of the energy in transmission and conversion.

No one would put a separate locomotive upon a tramline, if he could place the motor under the car. There are exceptional cases where a system of haulage is advantageous, such as the system of telpherage, the transport of goods along overhead rods carried on posts; but even the telpher locomotive must be provided with special appliances for obtaining a good grip upon the rods in lieu of rails. Another case is that of underground haulage in mines, where a number of small trucks have to be pulled along, and where it would be inconvenient to provide a motor for each truck in a train: but it is a strong point in favour of electric tramways that the motor can be made to form part of the vehicle carrying the passengers.

The construction of electric boats formed the concluding part of Mr. Reckenzaun's instructive lecture, which was listened to with marked attention and warm approval.

The President of the Association, Mr. George Williamson, moved a hearty vote of thanks to the lecturer, which was most cordially given.

MEMORANDUM UPON THE ELECTRIC LIGHTING ACT (1882) AMENDMENT BILL.

Presented by LORD RAYLEIGH *in the House of Lords.*

THE main object of this Bill is to amend the Electric Lighting Act, 1882, so as to place electric lighting undertakings in the same position as gas undertakings, both as regards privileges and obligations.

The chief provisions are—

1. That where electricity is not ascertained by meter, the consumer shall not use any lamp other than such as has been provided or approved of by the undertakers, or any lamp calculated to expend more electricity than he has contracted to pay for. This is done by clauses 3—6 of the Bill, which, in effect, re-enact (*mutatis mutandis*) the sections 18—20 of the Gasworks Clauses Act, 1847, without the exception as to the use of burners made by section 12 of the Electric Lighting Act, 1882.
2. Section 18 of the Electric Lighting Act, 1882, which expressly prohibited the undertakers from prescribing any special form of lamp or burner, is repealed; and instead, the proviso that where electricity is supplied by meter no local authority or person shall be at liberty to use any form of lamp or use the electricity supplied so as to interfere with the proper supply to other persons, is re-enacted substantively.
3. Section 27 of the Electric Lighting Act, under which local authorities may, after the expiration of 21 years, purchase the undertaking by paying the then value of all suitable lands, buildings, works, &c., of such undertakers without any addition in price, in respect of compulsory purchase, or of goodwill, or of any profits, is repealed.
4. The profits of undertakers are limited to the rate prescribed by the Provisional Order or Special Act, or where no rate is prescribed to 10 per cent. per annum. The principle whereby dividends are increased or diminished in inverse ratio to increase or diminution of price, is introduced on the method of the sliding scale applied to gas undertakings, except that having regard to the small price charged per electrical unit as compared with the price charged per 1,000 cubic feet for gas, the dividend is increased or reduced by 5s. per £100 in respect of every one farthing instead of 1d. as in the case of gas.
5. New or additional capital in the undertaking to be offered to the public by auction, in accordance with the usual auction clauses applied to gas undertakings.
6. The undertakers are to furnish a sufficient supply of electricity to owners or occupiers situate within 25 yards from the main.
7. The undertakers are to supply electricity for public lamps.
8. Mains are to be kept fully supplied.
9. Penalties similar to those of the Gas Acts are provided in case of default by the undertakers.
10. Local authorities to have similar powers of acquisition of the undertakings by agreement as are given them in the case of gas by the Public Health Act, 1875, sect. 162.
11. Penalties to be recovered summarily.

Society for the Protection of Life and Property from Lightning.—A pamphlet has reached us from Mr. W. McGregor, late Chief-Superintendent Indian Government Telegraphs, Assam division, the object of which is to set forth the necessity of a society for the protection of life and property from lightning. Steps are being taken for the formation of such a society, to consist of influential scientific and other persons, "to see that the simple rules—the outcome of patient and important scientific experiments, and the fruit of experience extending over 130 years—are not only published, but that the principles therein set forth are judiciously applied and strictly acted upon." Those who desire to learn more about the proposed society should communicate with Mr. McGregor, whose address is Kohima Lodge, Bedford.

NOTES.

The Lighting of the House of Commons. — Speaking in the House of Commons last week, Mr. T. P. O'Connor said the Irish members found the atmosphere of the House intolerable, and that this furnished an additional reason why they should have a Parliament of their own. He hoped the electric light would be introduced into the House instead of gas. Mr. H. Fowler remarked that the electric light had been already tried, and that an enormous majority of hon. members objected to it.

Electric Lighting on Railway Trains.—The *Mechanical World* says:—"The Railway Electric Lighting Company has been formed, to work certain patents for lighting railway carriages 'by electricity generated by the *momentum* of the train, and stored in accumulators.' It would have been better if they had waited until a company had been formed to overcome the *vis inertia* of railway directors."

Electric Lighting of Museums.—Last Friday, a motion was agreed to in the House of Lords to pray her Majesty to direct the opening of the National Gallery, the British Museum, and the Natural History Museum on three week-day evenings till 10 p.m. During the discussion which took place, Lord Sudely said that danger from fire seemed now to be greatly diminished by the introduction of electric lighting, as, if properly carried out, there could be no question that this system was much less harmful and dangerous than gas. With regard to the danger of the light going out opinions differed, and it was stated that if electric lighting were arranged with duplicate plant and the building were illuminated by two distinct circuits all possibility of the danger of the rooms being left in darkness was entirely removed. Even working with a single circuit at South Kensington and Bethnal Green no trouble whatever had arisen from this cause. The greatest difficulty in connection with the whole matter was undoubtedly the question of expense. The opening and illumination of these galleries and museums at night would mean the laying down of a considerable amount of plant for the electric lighting, together with its working expenses and annual maintenance; and also the employment of additional attendants and police. The total outlay in putting down this plant was very roughly estimated at £65,000, and the annual maintenance at £6,500.

The Electric Lighting Act.—In view of the second reading of the Bill introduced by Lord Rayleigh to amend and extend the Electric Lighting Act, 1882, the Electric Lighting Act Committee, of which Lord Thurlow is chairman, has re-issued its report, a copy of which was published in the REVIEW for March 21st, 1885. The committee has arrived unanimously at the conclusion that the electric light companies should demand to be put simply in the same position as the gas companies are, both as regards their privileges and their obligations, inasmuch as they believe no satisfactory solution of the question of general electric lighting can be arrived at by amending the Act on the basis of a modified purchase option clause, and the conclusion itself is clear and intelligible, and will commend itself to the public by its fairness and simplicity. Electric light companies may safely undertake the business of general lighting under conditions entirely similar to those of the gas undertakings, and the committee has prepared the draft of a Bill, which Lord Rayleigh has presented to Parliament. While unable to accept any purchase option clause, the committee thinks it quite right that all reasonable facilities should be given to local authorities to acquire electric lighting undertakings by agreement.

Theatre Lighting.—Mr. Ernest L. Berry is again to be congratulated on the successful completion of the second year's electric lighting at the Prince's Theatre, and Mr. Edgar Bruce, the lessee, appears to be more than ever convinced of its perfect adaptability for such purposes.

Electric Lighting of Milwaukee Bridges.—A project is being forwarded to locate and operate a 2,000 candle-power electric light on each of the 24 public bridges in Milwaukee, Wis. If carried out, this, it is said, will give to Milwaukee's harbour the best illumination of any on the lakes.

Telephone Exchange at Bath.—The Western Counties and South Wales Telephone Company is about to introduce into the ancient city of Bath the undoubted benefit of a telephone exchange, which, it is considered, will be of great aid in the facilitation of business. As is customary with this company, it has notified its intention of connecting the police stations, fire office, and hospitals, free of cost. The canvass of the town has met with considerable success, and the inhabitants will very soon have the advantage of not only local telephonic connection, but also of communication with Bristol. Mr. George Glover has been appointed agent to the company for the city and district.

The Telephone in Nottingham.—The *Nottingham Express*, of the 5th inst., gave a long account of the "rise and progress" of telephonic communication in Nottingham. The article states that the service was established in May, 1881, when trade being good and premises difficult to obtain, the company considered itself fortunate in securing the present Central Exchange in Bottle Lane. The exchanges (local) of the company are at Bottle Lane, Basford, Long Eaton, Loughborough, Ilkeston, and a call office has just been opened at the top of Derby Road, Nottingham. The company has about 316 miles of wires (chiefly overhead), exclusive of 40 miles erected for the use of the Municipal Corporation and its various departments. By this means the Municipal Offices in Albert Street are in constant communication with all the police and fire brigade stations, the Castle, the Eastcroft, the University College, Water and Gas Offices and Works, and the Borough Asylum. The Workhouse is also in communication with the Training Institution at Radford. A very large number of warehouses, offices, and factories are also connected with the system. There are now about twenty private residences in connection with the system. One very general application of the telephone is to put the residences of merchants and manufacturers in connection with their offices and works, both in the town and neighbourhood. Bottle Lane and all the subscribers are in direct communication with Loughborough, Long Eaton, Ilkeston, Bulwell, Basford, Carlton, Kimberley, and Arnold. The latest departure in connection with the local telephone is the establishment of a call office at the shop of Mr. Swinburne, watchmaker, in a block of recently-erected premises on the top of Derby Road, nearly opposite the General Cemetery gates. This office is now open to subscribers and the general public, and anyone in that locality by going there may communicate with the residence, office, or other place of business of any of the 337 subscribers who are connected with Bottle Lane, the public offices departments, police and fire stations, or principal public institutions. These call offices have been most successful in other parts of the country, more especially in the West Riding of Yorkshire, and it is felt that this single one, a preliminary experiment, only requires to become known and freely used to receive a large share of public patronage and favour. In that event, the company intends opening similar offices in all the other districts of the town.

The Proposed Telephone Conference.—Mr. W. E. Irish has sent us a lengthy communication upon this subject in reply to the letter of "Telephonist" in our last issue, but as much that he writes is beside the question, and is not likely to interest our readers, we are unable to publish it in full. Mr. Irish states that all patents for telephones which he has taken out are now public property; he then proceeds to describe in detail forms of his instruments which were fully dealt with in the REVIEW in the month of August last. These, he asserts, are outside the rightful claims of the United Telephone Company; but he has nothing to say upon the question whether they are (as has been contended) infringements of Prof. S. P. Thompson's inventions or not. His object, he says, in proposing a conference was to enable electrical engineers to consult together as to the best means of protecting themselves and their customers against "the monopoly." Such a conference might, he thinks, consider the advisability of opposing any application which may be made for the extension of the term for which patents have been granted to Bell and Edison, and of introducing a Universal Co-Operative Telephone Exchange System in every town throughout the country, by means of which the rentals would be reduced to a fractional part of the present cost. It might also protest against the State purchase of the monopoly, which is considered, in some quarters, to be probable. Mr. Irish may think that the discussion of these subjects will result in general benefit, but we have serious misgivings. We doubt if the opinions expressed at any assembly likely to take place upon the suggestion which Mr. Irish has made in our columns would carry much weight,

Improvements in Telephony.—An automatic call-box, the invention of Messrs. Blakey, Emmott & Co., Halifax, has just been brought into use at the call stations of the National Telephone Company at Bradford. One of the ordinary telephone instruments is fixed at the call station, which is usually a cabman's shelter or a tradesman's shop, and the automatic apparatus is fixed at the side of the instrument. Upon the person who wishes to speak dropping three penny pieces—a threepenny piece won't do—into the box, the weight of the coins moves an electric lever, which puts the speaker in communication with the exchange. On completion of the conversation, the exchange operator by reversing the current can break the connection again, and it requires three more pennies to obtain a further hearing. It is anticipated that these automatic boxes, which do away with the necessity for employing an attendant, will, if they prove satisfactory, enable the Telephone Company to extend its system of call stations considerably.

The Installation of Telephones on a Steamer.—We have received particulars of the installation of telephones on a steamer mentioned in our impression of March the 5th. The vessel was the *Anglo-Indian* steamer. The number of instruments was four, namely, one in engine room, one in steward's room aft, and two in the captain's deck house, and the circuits were deck house to engine room and deck house to steward's room, no switches being used. Wires had been run under the deck planks, but were found faulty, and new wires were run, while the frame of the ship was used as return circuit. "Earth" connection was made by soldering a strong wire on to a piece of galvanised iron plate one quarter inch thick, the plate being rivetted on to one of the ship's frames. The instruments were reported as working well a year after they were erected. The captain, who was also owner of the ship, is entitled to great credit for his enterprise, especially as it was quite in the early days of the telephone.

Long Distance Telephone Experiments.—Four new iron wires have lately been erected by the Post Office between London, Manchester, and Liverpool, on the "twist" or anti-induction principle. Some telephonic experiments were carried on between these places, but speaking was found to be practically impossible. Had these wires been constructed of copper, no doubt is expressed, from the result of Prof. Hughes's discoveries, that speaking would have proved to have been practical.

Local Authorities and Telephone Wires.—The Bill of the Nelson Local Board came before the Court of Referees (Mr. C. S. Parker in the chair) at the House of Commons last week, on the petition of the Lancashire and Cheshire Telephonic Exchange Company, Limited, for a *locus standi* to appear against the Bill. The Court decided that, as Parliament was very jealous of local authorities obtaining such legislative powers as were sought by the Bill unless the parties affected were heard upon the petition, in this case the *locus standi* would be allowed. We are informed that the Western Counties and South Wales Telephone Company has also succeeded in maintaining a *locus standi* against the Torquay Harbour Bill, in which the promoters have put a similar clause to that in the Bill referred to above.

Abbreviated Telegram Addresses.—Lord Wolverton, The Postmaster-General, has been memorialised from Yorkshire to reduce the amount charged for the registration of telegraphic addresses from £1 1s. to 5s. His Lordship has replied that the actual cost the department incurs in respect of each registration considerably exceeds the sum of 5s., and that any balance that may remain out of the charge of one guinea is far from being sufficient to meet the loss of revenue arising out of the reduction in the number of words in telegrams which is brought about by the use of an abbreviated address. The system is one which the department could never recommend to the public, and his Lordship considers that it would be contrary to his duty to do anything which would encourage any great extension of the system.

Electricity in the Royal Navy.—The electric light arrangements on board the barbette ship *Collingwood* at Portsmouth are now complete, the work having been carried out by Messrs. Siemens Brothers. The system employed is precisely the same as that on board the *Imperieuse*, a description of which has already appeared in these columns. There are altogether about 420 incandescent lamps distributed over every part of the ship. The electric light machinery on board the *Defiance* torpedo school ship at Devonport was tested on Friday last under the superintendence of Mr. Francis Ford, chief engineer of the ship, and Mr. Charles Rudd, second assistant to the chief engineer of the dockyard. A compound surface condensing engine drives the dynamo-electric machinery by the intervention of shafting and belting. The trial was pronounced to be highly satisfactory. Some interesting experiments were made at Dover last Friday with the 80-ton guns, which were fired by electricity. In all, eight charges were fired, six of these being full charges of 450 lbs. of prism. Excellent practice was made, and only one window in the town was broken.

To relieve the pressure in Portsmouth Dockyard some of the vessels are to be transferred to other yards. Though Portsmouth Yard is to continue the headquarters for torpedo fittings and experiments, it is intended to relieve it as a centre for the supply of electrical fittings for the fleet. It is consequently proposed to establish an electrical staff at Chatham, Sheerness, and Devonport, and as many trained workmen as can be spared are to be sent to those yards from Portsmouth.

The Development of Dynamic Electricity.—In the journal of the Franklin Institute for this month there appears a paper by Professor W. D. Marks, of Pennsylvania University, on "The development of dynamic electricity," in which he deals with the conversion of heat into electrical energy; the conversion of electrical energy into light; and the conversion of electrical into mechanical energy.

Partnership.—Mr. H. C. Harold, who is well known in connection with specialities in electric light fittings, has taken into partnership Mr. Robert Jenkins, and in future the name of the firm will be Harold and Jenkins.

The Electric Tramway at Ryde.—The president of the South-west of England District Association of Gas Managers has evidently not made himself well acquainted with the progress of electric tramways in the United Kingdom, if one may judge from his remarks after the opening of the Ryde Pier line. But as his comments were *post prandial*, some licence may perhaps be allowed.

FitzGerald's Secondary Battery.—With reference to Mr. FitzGerald's letter in our last issue M. Hospitalier writes to that gentleman as follows:—"You have altogether misinterpreted my letter to the ELECTRICAL REVIEW. I have said and I *maintain*, that the persons who have declared that I have made a report upon your battery have misused my name. This accusation is addressed to those who have supplied *false* information to the *Electrical Engineer*. I have therefore absolutely nothing to withdraw from the expressions of my letter. If you know the persons who have supplied the information to the *Electrical Engineer*, you can explain to them for me that I consider them as unscrupulous persons since they have made an absolutely false statement."

We regret that through a clerical error the translation of M. Hospitalier's letter to us, which was published in our "Notes" column for the 5th inst., made it appear that Mr. FitzGerald had been guilty of unduly making use of M. Hospitalier's name. The paragraph should have read "I consider the use which has been made of my name," &c., not "which *he* has made of my name." We ask Mr. FitzGerald's pardon for the unfortunate slip and take great pleasure in making the above correction.

Testing the Commercial Efficiency of Dynamo Machines.—Writing to the *Engineer* from the College of Science and Arts, Glasgow, Mr. Andrew Jamieson, the principal, says: In Mr. Kapp's description of the tests carried out at Messrs. Mather and Platt's works on the two Edison-Hopkinson dynamos, which appeared in the *Engineer* of last Friday, he gives at page 195, second column, the E.M.F. of Latimer Clark's cell as 1·453 volts. Now, in the report issued by Messrs. Mather and Platt it is stated that Lord Rayleigh's determination of the ohm and of the volt have been taken and not the B.A. units, consequently, if he accepted their resistances of the armature and field-magnets, &c., as stated in legal or in true ohms, the E.M.F. of the Clark cell used in connection with the experiments would of necessity also require to be reckoned in legal or in true volts, or about 1·12 per cent. less, say 1·441 legal volts. See Lord Rayleigh's latest communication to the Royal Society, January 21st, 1886, wherein he gives the E.M.F. of a standard Clark cell as being on August, 1885, = 1·4537 B.A. volts.

Lighthouse Illuminants.—The paper read on the 10th inst. on "Experiments with Lighthouse Illuminants at the South Foreland," by Mr. E. Price Edwards, before the Society of Arts, is published, together with the discussion thereon, in the Society's journal for last week. There is much contained therein of interest to the electrical engineer, the remarks of Mr. R. E. Crompton being very much to the point, for he shows that the electric light can as well be used for a small light as a big one, and that then instead of being two-and-a-half times dearer than oil, its cost might be reduced to one-and-half times less.

Secondary Battery Regulation.—A friend suggests that the trouble experienced by Mr. Littleton with the fluctuation of his incandescent lamps when the charging and discharging currents are about equal, is due to his gas engine. That is probably the case, but secondary batteries have hitherto been supposed to be capable of eliminating the irregular speed of motors. Is it not more likely that when the two currents are equal the secondary cells have nothing to give or take, and that, therefore, the pulsations in the dynamo current are then as apparent as if no battery is used in conjunction therewith. It does not appear from the correspondence on this subject that any others have worked under the precise conditions stated by Mr. Littleton.

The Resistances of Conductors.—Mr. J. Munro suggests that as a result of the experiments of Prof. Hughes on self-induction, it seems that the resistance of wires cannot be the same with a dynamo current that it is with a battery current. The latter is constant, the former intermittent, or, at all events, fluctuating. It follows, then, that conductors measured with battery currents will have different resistances with dynamo currents. This fact, says Mr. Munro, is certainly worth looking into to see what the difference amounts to and the practical value in electric lighting, &c. He also suggests that conductors for dynamo work should be measured with dynamo current and those for battery work with battery current; of course, "standards" made by battery currents will also give different values with dynamo currents if what is supposed be true.

At first sight it would appear that Mr. Munro's arguments might have considerable weight, but further consideration makes us more doubtful on the point. Everyone knows that when the resistance of an electro-magnet is being measured by means of a Wheatstone bridge, then if the galvanometer key is held down and the battery key is alternately raised and depressed, a series of "kicks" are obtained on the galvanometer; if a true resistance balance pure and simple has been obtained in the first place, then the kick on depressing the battery key is the same as that obtained on raising the key, but in the reverse direction. If now these makes and breaks occurred very rapidly, these kicks would annul each other and the needle would remain steady at zero, in other words a true resistance balance would be obtained; this would also be the case, we think, when a pulsatory current such as that given by a dynamo is being dealt with, especially with a galvanometer sluggish in its movements. We may add that Mr. Carl Hering, to an extent, forestalls Mr. Munro, as may be seen by referring to p. 250, line 5, of our present issue.

The First American Electric Patent.—In his recent lecture on Historical Electrical Apparatus, before the Franklin Institute, Chief Examiner Kintner, of the Electrical Department in the Patent Office at Washington, says the first electrical patent was granted to D. Harrington, a Philadelphian, in 1833, and that prior to 1881 there was no separate class for electrical patents. In that year it was made a separate class. The lecturer gave praise to the workmanship exhibited in models filed for patents.

An Appeal on Behalf of a much-valued Servant.—We should be spared the necessity of overburdening our capacious waste-paper basket, if Dr. Shaw, *alias* C. Frazier, *alias* Bonco, *alias* Blank, *alias* Banks, *alias* A. Lefevre, would for a time withhold his communications. We do not like to be cruel, but really what he has to say does not interest us much.

The De Khotinsky Secondary Battery.—Messrs Shippey Bros. send us the following:—It having fallen to the lot of our firm to instal the first set of batteries in England of the above system, we shall have much pleasure in allowing your correspondent, Mr. R. Mitchell, to inspect same, when he will find the batteries running side by side with the E.P.S. and Dr. Woodward's standard battery; he will then be able to judge for himself as to the difference between the three systems.

The Royal Society of Edinburgh.—A meeting of the Royal Society was held on Monday night, Sheriff Forbes Irvine, of Drum, vice-president, in the chair. Professor Blyth described a method of finding the strength of an electric current by means of an adaptation of the chemical balance.

The Railway Electric Lighting Company, Limited.—This company, recently alluded to in our pages 216 and 217, had, we understand, applications made for more than the full amount of capital offered. As, however, some three separate inventors had sent in legal notices of the invalidity, by reason of their respective patents, of the Houghton-Stroudley inventions, it was deemed advisable to return the applicants their moneys in full. The company entitled the Railway Electric Contractors, Limited, will, it is said, carry on the business as before, and for that purpose, and to extend the same, will take more capital; and thus the aims of those who served the afore-mentioned notices will be, justly or unjustly, at least for a time, defeated.

Edinburgh International Exhibition.—At a meeting of the executive committee, last week, it was resolved to light the grounds by electric light, supplemented, if necessary, by variegated Chinese lanterns artistically distributed amongst the trees. The tender by Messrs. King, Brown and Co., for electric lighting, was accepted.

Removal.—Mr. Ronald A. Scott has removed from 31, Basuto Road, Fulham, to larger premises at 331, King Street, Hammersmith, W.

Accumulator Plates.—A correspondent writes, just as we go to press, asking if there is any valid patent for the application, by mechanically spreading, of peroxide of lead or minium to the plates of secondary batteries.

The Holmes-Burke Primary Battery.—It is stated that at a recent trial of the Holmes-Burke primary battery, 40 of these cells lighted a Brockie-Pell lamp of 2,000 candle-power, taking 12 ampères for 17½ hours continuously with a single charge.

Fatal Gas Explosion.—On Tuesday afternoon two children were killed and six persons injured by an explosion of gas in a house in Coppall Lane, Wigan. As no gas was used in the house it is probable a searching inquiry will be made to ascertain from whence it escaped.

Gas Engines.—Gas-engine litigation, remarks *Gas and Water*, has had its innings in England, in Germany, and in France. Recently an agitation of a different nature, yet relating to gas-engines, arose in America. In the Republic, as elsewhere, the makers of the Otto gas-engine claim a large percentage of economy for it, and they court and have courted comparison with other makers in this respect. At the American Institute Exhibition one of these engines was entered for competition. The challenge was accepted by the Clerk Gas-Engine Company, and the conditions were duly announced. The exhibitors were to supply the weight of the engine, price, claimed horse-power, and the test was stipulated to last two hours for each engine at full power, and was to bear upon the economy as well as the power of the engine. Four well-known engineers acted as judges, and they report that "the results as regards consumption of gas were practically identical—the difference being only one-fifth of a cubic foot per effective horse-power per hour. Outside of this we find very commendable features in both engines, especially in the Clerk; but in view of the paramount importance of the item of consumption of fuel in gas-engines, we do not feel justified in deciding upon the relative merits of both engines solely upon points of design and workmanship, and, therefore, we would recommend a more thorough and longer test, which will bring out the difference in economy, if any, or prove beyond question the equal standing of the two engines on that score." From the statement of the tests it appears that the cubic feet of gas used per hour was:—Otto 236·55, Clerk 293·65; horse-power by brake, Otto 9·6, Clerk 12·007; cubic feet of gas per brake horse-power per hour, Otto 24·64, Clerk 24·44 These facts speak for themselves.

Messrs. H. and E. J. Dale's Catalogue.—The third edition of this descriptive price list of electrical and physical apparatus has just been issued. It is not only a price list, but also a guide to the use and fitting of all forms of apparatus, useful alike to the science teacher, the amateur or experimentalist and the commercial buyer. The prices are revised to date, and many novelties are described and illustrated in this new issue.

Electric Light at the Aquarium.—At the close of last year the lighting of this place of amusement, which has recently, by dint of vigorous management, regained much of its former popularity, was placed in the hands of the Gülcher Electric Light and Power Company. The installation has now been in successful working for nearly three months, and the brilliancy and steadiness of the lights has been a marked success. There are seven lamps of 2,000 candle-power lighting the exterior of the building and 16 of 3,000 candle-power throughout the interior. The whole are fed from three 65 volt machines driven by a 16 H.P. Robey engine.

The Society of Telegraph-Engineers and Electricians.—The next meeting at the Institution of Civil Engineers, 25, Great George Street, S.W., will take place on Thursday, the 25th March, at 8 p.m., when the following paper will be read:—"Electric Lighting by Means of Low Resistance Glow Lamps," by Alexander Bernstein.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Pocklington New Lighting Company, Limited (gas and electricity).—The first annual return of this company, made up to the 8th inst., was filed on the 9th inst. The nominal capital is £3,000 in £1 shares; 1,277 shares have been taken up and a call of 2s. 6d. was made upon allotment. The total calls paid, including those paid in advance, amount to £269. Registered office Union Street, Pocklington, York.

Maxim-Weston Electric Company, Limited.—The annual return of this company, made up to the 5th inst., was filed on the 15th inst. The nominal capital is £125,000, divided into 500,000 shares of 5s., having been recently reduced by £62,500 by cancelling paid-up capital unrepresented by available assets (being patents over-estimated in value). The total amount of calls received is £61,700, and £800 is considered as paid on 3,200 shares.

Jarman Electrical Company, Limited.—An extraordinary general meeting of this company was held on the 22nd ult., at 6, Great Winchester Street, when the following resolution was passed: "That the liquidator be authorised to waive and cancel the agreements entered into between the Jarman Company, C. P. Eliesen and Edwd. Spendlove, as trustee on behalf of the Electric Locomotive and Power Company, Limited, and between the liquidator, C. P. Elieser and the last named company, dated respectively, 31st July, 1885, and 19th September, 1885, and in lieu thereof to enter into a fresh agreement proposed to be made between the liquidator of this company, C. P. Eliesen, and the Electric Locomotive and Power Company, Limited, for the sale of the business effects and property of the Jarman Company in consideration partly of fully paid-up shares in the Electric Locomotive and Power Company, Limited, and cash and bills to be paid, given, and transferred upon the terms and conditions set forth in the draft of the said agreement, and which draft, for the purpose of identification, is signed by the chairman, Mr. George Hamilton." This resolution was confirmed on the 10th inst. and duly filed on the 15th inst.

Simplex Electrical Syndicate, Limited.—An agreement dated 27th ult., and filed on the 10th inst., relates to the purchase by this company of the business of electricians carried on by Messrs. G. Alanson Mason, Otto Romanze, Fredk. Thornton, and Wm. Weise, at 9, North Street, Wandsworth, together with certain patented and other inventions relating to the construction of electric arc lamps, secondary batteries, or electrical accumulators, and other electrical apparatus and appliances. The purchase consideration is £300 in cash and 60 fully paid shares of £50 each.

International Electric Company, Limited (in liquidation).—The registered office of this company is now situate at 14, George Street, Mansion House.

CITY NOTES, REPORTS, MEETINGS, &c.

Direct Spanish Telegraph Company, Limited.

THE report of the directors states that the accounts for the half-year ended December 31st, 1885, show, after paying for the repairs of the new Bilbao cable (£2,959 13s. 7d.) and providing for debenture interest, a balance to the credit of profit and loss of £1,449 5s. 2d.

The traffic receipts show an increase of £287 14s. 9d. as compared with the corresponding half-year of 1884, and an increase of £1,111 12s. over those of the last half-year.

The repairs of the new Bilbao cable, the interruption of which was mentioned in the last report of the Board, were promptly and economically effected. The cause of this break, which occurred in very deep water, cannot be ascertained. The entire cost of these repairs, it will be noticed, has been paid out of the revenue for the half-year.

The new Bilbao cable has, since the repairs, worked perfectly. The Marseilles-Barcelona cable has remained in excellent working order throughout the half-year.

The directors are arranging to have the original Bilbao cable examined in the course of this summer, with a view to ascertain its condition.

The directors propose to put £1,400 to the reserve fund, which will then amount to £9,800, and to carry £49 5s. 2d. to the next account.

The Telephone Company of Egypt, Limited.

THE ordinary general meeting was held on Tuesday at the offices, Austinfriars, Lieutenant-General A. Fraser, C.B., R.E., in the chair. The report of the directors stated that, including the balance of £165 brought forward, there was an available balance (after providing for income tax and writing off £300 in reduction of capital for depreciation) of £3,210, out of which they recommended a dividend at the rate of 5 per cent. per annum, leaving a balance of £192 to be carried forward. The dividend now payable had, in accordance with the articles of association, to be applied in the following manner:—2 per cent. in final payment of the cumulative preferential dividend of 7½ per cent. per annum for 1883, and 3 per cent. in part payment of the cumulative preferential dividend of 7½ per cent. for 1884, leaving 4½ per cent. for the year still due. In order, however, that the earnings of the present and future years might be applied specially to the payments of dividends for those years for which the accounts were issued, an alteration of the articles of association was now contemplated. On the motion of the chairman, seconded by Mr. G. B. Frost, the report was adopted and the dividend recommended declared. The retiring directors and auditors were afterwards re-elected.

National Company for the Distribution of Electricity by Secondary Generators, Limited.—The third ordinary general meeting of this company was held at the offices, Warwick Street, Regent Street, on Thursday, under the presidency of Mr. Wm. D'Oyly, when the report, printed in our last issue, was adopted, and a dividend of 10 per cent. on the preferred shares was declared.

German Union Telegraph and Trust Company, Limited.—A final dividend of 4s. 3d. per share is recommended, free of income-tax, on the 22nd inst., making a total dividend of 10s. on the year to December 31st, 1885.

TRAFFIC RECEIPTS.

The West India and Panama Telegraph Company, Limited. The estimated receipts for the half-month ended the 15th March are £2,892, as compared with £2,865 in the corresponding period of 1885.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending March 12th were £2,449, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited.

The Brazilian Submarine Telegraph Company, Limited. The receipts of last week amounted to £3,032.

PROCEEDINGS OF SOCIETIES.

The Society of Telegraph Engineers and Electricians.

AN ordinary general meeting of this society was held on Thursday, March 11th, Professor HUGHES, F.R.S., president in the chair. The minutes of the last ordinary general meeting having been read and confirmed, and the list of new and proposed new members announced, a paper on "Economy in Electrical Conductors," by Professors W. E. AYRTON, F.R.S., and JOHN PERRY, F.R.S., was read as follows:—

I.—At the meeting of the British Association in 1881, a most valuable solution of a very important problem was given by Sir William Thomson regarding the proper sectional area to give to a copper conductor used in transmitting electric energy. In the account of his communication given in the "Report of the British Association" for that year, it is stated that "he remarked that (contrary to a very prevalent impression and belief) the gauge to be chosen for the conductor does not depend on the length of it through which the energy is to be transmitted. It depends solely on the strength of the current to be used, supposing the cost of the metal and of a unit of energy to be determined." And he concluded that for twelve hours per day work "the sectional area of the wire in centimetres ought to be about a fiftieth of the strength of the current in webers."

It is, of course, well known that this rule has to be departed from when considerations have to be taken into account other than that of obtaining maximum economy: for example, the necessity in any general system of electric lighting of maintaining the potential difference along the mains constant within certain limits, may lead us to adopt a thicker conductor than is given by the rule of 1 square centimetre per 50 ampères; while on the other hand, our desire to obtain a large magnetic effect in an electromagnet, or a large electromotive force in a dynamo, induces us to employ a much thinner conductor than the rule indicates. But, at any rate, when the cost of copper and the cost of coal are the leading considerations, it might appear that Thomson's rule ought to be rigidly adhered to, proper allowance being, of course, made in any particular case for the number of hours of working, the cost per ton of copper, the annual rate of interest and depreciation, and the annual cost of an electric horse-power. Indeed, this is the view that we, and possibly other electrical engineers, have taken, and it was not until comparatively recently, when in actual calculations regarding the proper dimensions to give to the conductors in telpher lines, that we recognised that Thomson's solution of the most economical section to give to a conductor was quite inapplicable in a variety of cases connected with electric transmission of power.

II.—Let us consider a little more in detail the solution that Thomson gave. He arrived at an expression for the total waste per mile in a conductor arising from the generation of heat and interest on copper which we find convenient to put in the following form:—

$$\mathrm{c}^2 r + \frac{t^2}{r} \qquad (1)$$

where c is the current in ampères, r the resistance of the conductor per mile in ohms, and t a constant which depends on the annual interest on the value of a ton of copper (allowing for depreciation) and the annual cost of an electric horse-power for the number of hours per year that power is required. Our expression (1) is, in fact, the *total* rate of waste per mile, *reckoned in watts.**

In order that this may be a minimum for a given value of c,

$$\mathrm{c} = \frac{t}{r}. \qquad (2)$$

If we take £15 as the annual interest (allowing for depreciation) per ton of copper (that is to say, about 12 per cent. on £125—a fair price per ton for good conductivity copper, including the value of the necessary amount of insulation), and if we take £15 also as the annual cost of an *electric* horse-power for the number of hours per year that power is required, it is easy to show that

$$t^2 = 297{\cdot}3;$$

so that (2) reduces itself to

$$\mathrm{c} = \frac{17{\cdot}24}{r}$$

$$= \frac{17}{r} \text{ approximately} \qquad (3)$$

corresponding with about 60 ampères per square centimetre, or 393 ampères per square inch.

Now suppose that we desire to apply this result to such a case as the following, which will frequently be met with in electric lighting and transmission of power:—What size of copper conductor ought to be employed when a certain amount of power, P watts, has to be furnished at the end of a conductor n miles long, and when the highest potential difference we are allowed to use from considerations of safety, or, it may be, that is allowed us by the Board of Trade, is V volts?

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* Although it would not avail bankers to reckon that a business which cleared £1,500 a year produced so many watts, yet such a mode of reckoning is very convenient in problems like the one under consideration. With an electric horse-power costing £15 per annum the business clearing £1,500 annually might be regarded as producing 74,600 watts, and 5 per cent. per annum interest on £120 might be regarded as an income of 298·4 watts.

Let C be the current in ampères, then, since the maximum potential difference must be at the near, or dynamo, end of the line, the potential difference at the farther end will be

$$V - C\,n\,r,$$

if r is the resistance per mile of the conductor in ohms, and if the earth be used as the return; or if r is the resistance per mile of the going and returning conductor,

$$\therefore P = C\,(V - C\,n\,r) \qquad (4)$$

and, by Thomson's rule,

$$C = \frac{t}{r};$$

hence we have two equations from which to determine C and r. The values of C and r so obtained are—

$$C = \frac{P}{V - n\,t} \qquad (5)$$

and

$$r = \frac{t\,(V - n\,t)}{P} \qquad (6)$$

and these are the values of C and r which, it might appear, ought to be selected in order to obtain maximum economy.

As an example, let

P = 10,000 watts,
V = 200 volts,
n = 10 miles,
t = 17;

then, from (5) and (6),

C = 333 ampères,
and r = 0·051 ohm.

But it is easy to see from (4) that with an initial potential difference of 200 volts the same power, 10,000 watts, can be delivered at the end of 10 miles of a conductor having the same resistance per mile if, instead of using 333 ampères, we use only 59 amperes; and as the loss of power in heating is proportional to the square of the current, the waste in heating when using the smaller current will be only about the twenty-sixth part of what it would be if we used the current given us by equation (5).

In fact, for each value of r there are two solutions of C which satisfy (4), whereas only one of them can satify Thomson's equation of economy (2). In this example, then, 31 times as much economy in coal will be obtained by neglecting Thomson's rule as by following it.

III.—Now what is the explanation of this? The cause cannot, of course, be due to any error in Thomson's reasoning, and it arises from the fact that Thomson's solution gives the minimum value of the expression

$$C^2 r + \frac{t^2}{r}$$

only when C is regarded as a constant, and r as the *sole* variable. But if, as in the present case, both C and r in this expression are variables connected by some equation such as

$$f\,(C, r) = 0,$$

then the equation connecting C and r which makes the total waste a minimum is *not*

$$C = \frac{t}{r}.$$

In fact, when the maximum difference of potentials, V, is fixed, the current, C, can only be regarded as a constant when the power *put into the line at the dynamo end*, V, C, is given, and when the amount delivered at the other end is, so to say, left to chance. Under these conditions Sir William Thomson has given us a most useful rule for determining the size to give to the conductor to obtain maximum economy, but his solution can only be used when the value of the current is previously known.

But since in many practical cases it is the amount of power that has to be furnished at the distant end of the line that is fixed for us by the contract, C must not be regarded as a constant, and a totally different method must be employed to obtain the size of conductor to be employed so that the waste of power in heating the conductor, together with the interest on the value of the copper, may be a minimum. For not merely, as we have shown, does the current of 333 ampères and a resistance of 0·051 ohms per mile, as determined from (5) and (6), lead to 31 times as much waste in heating as will be produced by using the equally effective current of 59 ampères with the same conductor, but, as we shall show, there is a solution of the problem even more economical than this.

IV.—If we write F (C, r) for the total rate of waste, which is

$$C^2 r + \frac{t^2}{r},$$

and if our supply condition connecting C and r is

$$f\,(C, r) = 0,$$

then the equation which gives us the minimum is

$$\frac{d\,F}{d\,C} \times \frac{d\,f}{d\,r} - \frac{d\,F}{d\,r} \times \frac{d\,f}{d\,C} = 0.$$

Hence, performing the partial differentiations on our two functions (1) and (4), we have

$$2\,C\,r \times C^2 n - \left(C^2 - \frac{t^2}{r^2}\right)(2\,C\,n\,r - V) = 0 \qquad (7)$$

Eliminating r from (4) and (7), we obtain

$$C^2 - 2\,C\,\frac{P}{V} + \frac{P^2}{V^2 + n^2 t^2} = 0 \qquad (8)$$

$$\therefore C = \frac{P}{V}\left(1 \pm n\,t\,\sqrt{\frac{1}{V^2 + n^2 t^2}}\right),$$

and, as C V, which is the power put in at the dynamo end of the line, must necessarily be greater than P, the power given out at the distant end, it follows that the plus sign is alone admissible. Hence the current which must be used to obtain maximum economy is

$$\frac{P}{V}\left(1 + n\,t\,\sqrt{\frac{1}{V^2 + n^2 t^2}}\right) \qquad (9)$$

Substituting the values employed in the previous example for P, V, n, and t, we find that the current which gives maximum economy is 82 ampères; and, from (4),

$$r = \frac{C\,V - P}{C^2 n}; \qquad (10)$$

so that the resistance per mile that gives maximum economy is 0·0954 ohm, and *not* 0·051 ohm.

We may now use the three sets of values of C and r that we have obtained in connection with our example, and find what values they give to the expression

$$C^2 r + \frac{t^2}{r},$$

which represents the total rate of waste, reckoned in watts, due to the production of heat in the conductor, and to the interest, including depreciation, on the value of the conductor.

A. Using the values of C and r given by (5) and (6), obtained from combining Thomson's condition of maximum economy with the condition of electrical supply, we have for the above expression

$$333^2 \times 0{\cdot}051 + \frac{289}{0{\cdot}051} = 5{,}654 + 5{,}666$$
$$= 11{,}320 \text{ watts per mile.}$$

B. Using the value of r given by (6), and the second value of C given by (4), we have for the above expression

$$59^2 \times 0{\cdot}051 + \frac{289}{0{\cdot}051} = 177 + 5{,}666$$
$$= 5{,}843 \text{ watts per mile.}$$

C. Using the values of C and r given by (9) and (10), the proper equations to be used for obtaining maximum economy, we have for the total waste

$$82^2 \times 0{\cdot}0954 + \frac{289}{0{\cdot}0954} = 641 + 3{,}030$$
$$= 3{,}671 \text{ watts per mile.}$$

Although, then, the current of 82 ampères and the resistance of 0·0954 ohms per mile lead to a greater waste in heating than the current of 59 ampères and the resistance of 0·051 ohms per mile, yet the former are the most economical to employ. In fact, it will be found that a conductor having a resistance per mile either greater or less than 0·0954 ohms leads, in our example, to greater waste than is produced by employing this conductor.

V.—For the purpose of constructing a table to be used for determining the proper current and resistance of conductor per mile to be selected in various cases in order to obtain maximum economy, and for determining the waste that will occur per mile in heating, and the amount of interest on the value of the copper per mile, when this current and resistance per mile are employed, let

$$\frac{n\,t}{V} = \tan.\ \phi;$$

then

$$C = \frac{P}{V}\,(1 + \sin.\ \phi) \qquad (11)$$

and

$$r = \frac{V^2}{n\,P} \cdot \frac{\sin.\ \phi}{(1 + \sin.\ \phi)^2}. \qquad (12)$$

Using these values, the following table (No. I.) has been calculated for V equal to 200 volts, and P equal to 20,000 watts, for the purpose of illustrating the variations in current, resistance per mile, &c., proper to be employed to obtain maximum economy with wires of various lengths. The first column gives n, the number of miles at the end of which this power is to be furnished if the earth be used as the return. If the earth be not used as the return, then n will be *twice* the distance between the two ends of the line. The second column is $\frac{n\,t}{V}$, where t is taken as 17. The third and fourth columns give ϕ, and sin. ϕ; the fifth and sixth the current (C) in ampères that should be employed, and the resistance (r) in legal ohms per mile that should be given to the conductor to obtain maximum economy; column 7 gives the sectional area (A) of the conductor in square inches, the resistance of one mile of copper wire of 98 per cent. conductivity at 20° C., one square inch in section, being taken as 0·04378 legal ohms. Column 8 gives D, the current density—that is, the number of ampères per square inch; columns 9 and 10 P_1, the power, in watts, wasted in heat per mile, and P_2, the watts wasted per mile as interest, including depreciation, on the value of the conductor. The last column contains the values of P_3, the total rate of waste, in watts, per mile.

TABLE I.

To furnish 20,000 watts at the end of n miles.

1	2	3	4	5	6	7	8	9	10	11
n	$\frac{17}{200} n$	ϕ	sin. ϕ	C	r	A	D	P_1	P_2	P_3
·1	·0085	0° 29′	·0084	100·8	·1652	·2651	380·2	1679	1749	3428
·5	·0425	2° 26′	·0425	104·3	·1564	·2800	372·5	1699	1847	3546
1	·085	4° 52′	·0848	108·5	·1441	·3038	357·2	1695	2005	3700
2	·17	9° 39′	·1677	116·8	·1229	·3563	327·8	1675	2351	4026
4	·34	18° 47′	·322	132·2	·0921	·4753	278·1	1609	3137	4746
6	·51	27° 2′	·4545	145·5	·0716	·6115	238·0	1514	4036	5550
8	·68	34° 13′	·5623	156·2	·0575	·7614	205·1	1403	5026	6429
10	·85	40° 22′	·6477	164·8	·0477	·9179	179·5	1295	6058	7353
15	1·275	51° 54′	·7869	178·7	·0328	1·335	133·9	1047	8810	9857
20	1·7	59° 32′	·8619	186·2	·0241	1·817	102·5	835	11911	12746
30	2·55	68° 35′	·931	193·1	·0166	2·637	73·2	618	17530	18148
50	4·25	76° 46′	·9735	197·4	·0099	4·423	44·6	385	29191	29576
70	5·95	80° 27′	·9861	198·6	·0071	6·166	32·2	280	40704	40984
100	8·5	83° 18′	·9932	199·3	·0049	8·935	22·3	194	58979	59173

The latter portion ef this table has been calculated merely for the purpose of illustrating how the current, sectional area of the conductor, and current density necessary to be used to obtain maximum economy vary with the length of the line, and not because anyone would think of attempting to transmit 30 horse-power 50 or a 100 miles with a potential difference of only 200 volts at the dynamo.

The problem considered by Sir William Thomson led to the result that in order to obtain maximum economy the area of the conductor depended solely on the current, and was independent of the length of the line, or, in other words, the current-density was a constant. But from the preceding table we see that *if a given amount of electric power has to be furnished at the end of a line, with a given potentiol difference at the dynamo, maximum economy is obtained, not by keeping the current-density constant, but by making it diminish as the length of the line becomes greater.*

In order to employ this table for other amounts of power to be furnished at the distant end of the line, it is to be observed that since

$$C = \frac{P}{V}(1 + \sin.\phi) \tag{13}$$

$$r = \frac{V^2}{n P} \cdot \frac{\sin.\phi}{(1 + \sin.\phi)^2} \tag{14}$$

and since the sectional area of the conductor,

$$A = \frac{0{\cdot}04378\, n P}{V^2} \cdot \frac{(1 + \sin.\phi)^2}{\sin.\phi} \tag{15}$$

it follows that, with the same initial potential difference, the most economical current to employ is directly proportional to the power to be furnished at the distant end, the most economical resistance per mile to give to the conductor is inversely proportional, and the most economical sectional area directly proportional, to the power that has to be furnished at the distant end of the line.

VI.—In the construction of telpher lines we use steel rods both to carry the load and to carry the conductor. In order, then, to see how the numbers in Table I. must be altered if steel be used instead of copper, we must see how the value of t is altered. Now, since

$$t^2 = 67{\cdot}84 \frac{i \times c \times \rho}{p},$$

where i is the yearly interest, including depreciation, on money invested in conductors; c the value, in pounds, of a ton of the metal used in making the conductor, together with the value of the necessary amount of insulation; ρ the resistance of a wire one mile long and one square inch in section of the material employed in making the conductor; and p the annual cost, in pounds, of an electric horse-power for the number of hours that power is required. Now the specific resistance of steel bears to the specific resistance of copper, approximately, the inverse ratio of the cost per ton of steel to the cost per ton of copper; hence the product $c\,\rho$ for steel will be roughly the same as the $c\,\rho$ for copper, and consequently the value of t may for a rough approximation be regarded as unaltered. All the columns, therefore, in Table I. will remain roughly the same if steel be used in place of copper, with the exception of column 7, giving the sectional areas, and column 8, the number of ampères per square inch.

Also all the columns will remain unaltered as long as $\frac{i \times c}{p}$ is constant; for example, no change will be necessary if the yearly interest, including depreciation, be taken as £10, instead of £15, and if the yearly value of an electric horse-power be also taken as £10 instead of £15.

VII.—We may take as an example of the use of the results obtained by this investigation the case of the electric transmission of power from Paris to Creil by M. Deprez. The distance was 37½ miles, and as a wire was used for both the going and return conductors, n equals 75; the potential difference at the dynamo (V) was about 5,600 volts, therefore

$$\tan.\phi = \frac{n t}{V}$$

$$= 0{\cdot}2278,$$

$$\text{or } \phi = 12^\circ\, 50'.$$

Hence, as the power furnished at the distant end of the line (P) was about 30,000 watts,

$$C = 6{\cdot}549 \text{ ampères},$$

$$\text{and } r = 2{\cdot}073 \text{ ohms}.$$

give the values of the current and the resistance per mile of the line that should be used to give maximum economy; or, since the line is 75 miles long, the total resistance should equal 155·5 ohms.

M. Deprez actually used a current of about 7·2 ampères, and the total resistance of his line was 100 ohms. We do not know on what principle he calculated the size to give to his conductor, which was a copper wire 5 millimetres in diameter, but the current conveyed was at the rate of about 36·6 ampères per square centimetre. The above, however, shows that the most economical current, using 17 for the value of t, would have been at the rate of 47·7 ampères per square centimetre. But as his object was rather to show economy in electric transmission of power, irrespective of first cost, than to show economy in copper used, and as when he began his experiments he was probably not quite sure of the potential difference at which his dynamo would give out electric power, we think that he was quite right in using a thicker conductor than our calculation shows would have produced the minimum total waste.

We have already seen that when we have to supply a given amount of electric power at the end of a certain line, using a given potential difference at the dynamo, the current density to be employed to obtain maximum economy diminishes as the length of the line increases. Thomson's rule for the current density is obtained from his equation for maximum economy—

$$C = \frac{t}{r},$$

and the equation

$$A = \frac{0{\cdot}04378}{r}$$

$$\therefore D = \frac{t}{0{\cdot}04378},$$

which is independent of the length of the line.

For t equal to 17 his D equals about 393 ampères per square inch. We see, therefore, that this current density exceeds that given for all the lengths of line, even for the shortest—0·1 mile or 170 yards—in column 8 of Table I., although in calculating this table the same value was employed for t; that is, the same values were used for the yearly rate of interest, for the price of copper wire per ton, with its necessary insulation, and the same cost per year for an electric horse-power for the number of hours power is required. In order to see whether for any distance, or for any amount of electric power to be supplied at the end of this distance, it is economical to use so large a current density as is given by Thomson's rule, we will find an expression for our current density. Dividing the expression given for C in (13) by that for A in (15), we have

$$D = \frac{V}{0{\cdot}04378\, n} \, \frac{\sin.\phi}{(1 + \sin.\phi)};$$

hence, as

$$\tan.\phi = \frac{n t}{V},$$

$$D = \frac{V}{0{\cdot}04378} \cdot \frac{t}{n t + \sqrt{n^2 t^2 + V^2}} \tag{16}$$

Now this is independent of P, the number of watts to be supplied at the end of the line; hence all the values of D, in column 8, Table I., being smaller than the current density given by Thomson's formula for maximum economy has nothing to do with the amount of power that is to be supplied. Further, we see that the value of D in (16) can only equal $\frac{t}{0{\cdot}04378}$, the value of D given above by Thomson's formula, when either V is extremely large or n extremely small. Hence we may conclude that in all problems connected with the electric transmission of power where the maximum potential difference that we may use is fixed for us by the Board of Trade, or otherwise, a smaller current density than that given by Thomson's formula must be used to obtain maximum economy, and the longer the line the smaller must this current density be; also, the smaller the maximum potential difference that may be employed, the smaller must the current density be to obtain maximum economy.

VIII.—We have discussed at some length the conditions of maximum economy when a given amount of power has to be supplied at a given distance with a given potential difference at the dynamo, on account of its wide practical importance; but there are many other practical cases which we have not thought it necessary to discuss in which there is an initial relation connecting C and r. One example may, however, be referred to.

Let there be a level electric railway extending n miles in one direction from the engine house, on which one train is running requiring P watts to propel it at a uniform speed of v miles per hour. Let the resistance of the conductor conveying the power from the dynamo to the train be r ohms per mile, and let V be the constant potential difference at the dynamo. At a time (τ)

reckoned from the time the train is at the engine house let it be at a distance x miles along the line, then

$$\mathrm{P} = \mathrm{C}\,(\mathrm{V} - \mathrm{C}\,x\,r),$$
$$x = \mathrm{V}\,\tau,$$
$$d\,x = v\,d\,\tau.$$

When the train is at a distance x the rate of wasting power, in watts, is

$$\mathrm{C}^2\,x\,r + n\,\frac{t^2}{r};$$

therefore the waste, in joules, in a time $d\,\tau$ is

$$\left(\mathrm{C}^2\,x\,r + n\,\frac{t^2}{r}\right) d\,\tau;$$

hence the loss in the whole line n miles long is

$$\frac{1}{v}\int_0^n \left(\mathrm{C}^2\,x\,r + n\,\frac{t^2}{r}\right) d\,x,$$

and maximum economy will be effected by selecting C and r so that this expression is a minimum when C and r are connected by the first equation given above.

IX.—Hitherto we have been dealing with a conductor giving off power only at one point—either at its end, or, as in the last problem, at a point the position of which varies from time to time; but in telpherage, and in many systems of electric lighting and transmission of power, we have to deal with a conductor giving off in every mile the same amount of electric energy, which, bear in mind, does not mean giving off the same amount of current per mile, since there is a diminishing potential difference as we proceed along the conductor from the dynamo. This problem we deal more fully with in another paper. But if we suppose that an independent conductor takes the required supply of energy to every short length of line—that is, if a number of feeders are employed—we can at once use the results that we have already obtained to determine the most economical amount of copper to employ.

Having determined the most economical size of separate conductor to convey the power to each point of the line of distribution, we may for practical purposes imagine all the conductors connected together metallically so as to form a tapered conductor. As, however—if we imagine such a metallic joining together of the separate conductors—currents will flow through the connections, because the potentials at a point where a connection is going to be made differ from one another in the various conductors, it follows that a conductor of the aggregate section of all the small conductors at every place will not be as economical as would be a conductor whose section at every place was independently determined from the considerations which are given by us in our other paper. However, taking the section of the tapered conductor to be equal to the sum of the sections of the separate conductors which distribute the energy with maximum economy, we find that the following is the result:—

Let the section of a conductor to transmit with maximum economy P watts n miles with a given potential difference be called

$$\mathrm{P}\,f\,(n);$$

then

$$\int_x^{x_1} \mathrm{P}\,f\,(x)\,d\,x$$

is the aggregate section at a point x miles from the dynamo when the end of the line is x_1 miles from the dynamo. It is easy to obtain an exact integral, using (15) for P $f\,(x)$, but we have preferred to integrate from a curve giving the value of A or P $f\,(x)$ when P is 20,000 in column 7 of Table I.

In this way we have, for the purpose of illustration, calculated Table II., which gives the most economical sectional area, in square inches, at the end of each mile when the conductor *tapers* according to the law just mentioned; it is calculated for a potential difference of 200 volts at the engine house, and for a power of 5,000 watts given off in every mile. The four horizontal rows give the sectional area, in square inches, of the tapered conductor at the end of each mile, when the total length of the conductor is respectively 3, 5, 8, and 10 miles.

TABLE II.

Total length of conductor from engine house, in miles.	Area, in square inches, of the tapering conductor at the end of										
	0	1	2	3	4	5	6	7	8	9	10 miles.
3	0·24	0·17	0·09	0							
5	0·47	0·40	0·32	0·23	0·12	0					
8	0·94	0·88	0·79	0·70	0·60	0·47	0·33	0·18	0		
10	1·35	1·28	1·20	1·11	1·00	0·88	0·74	0·58	0·41	0·21	0

Table III. gives the current, in ampères, flowing through the conductor at the end of each mile in each of the various cases described above.

TABLE III.

Total length of conductor from engine house, in miles.	Current, in ampères, flowing through the tapering conductor at the end of										
	0	1	2	3	4	5	6	7	8	9	10 miles.
3	85·7	59·6	31·4	0							
5	151·8	125·7	97·5	66·1	34·0	0					
8	262·9	236·8	208·6	177·2	145·1	111·1	75·5	38·4	0		
10	343·2	317·1	288·9	257·5	225·4	191·4	155·8	118·7	80·3	40·7	0

Table IV. gives the current density at the end of each mile in each of the cases described above.

TABLE IV.

Total length of conductor from engine house, in miles.	Current density in the tapering conduotor at the end of										
	0	1	2	3	4	5	6	7	8	9	10 miles.
3	357·2	350·5	348·9	0							
5	322·9	314·2	304·7	287·4	283·2	0					
8	279·7	269·1	264·1	253·1	241·8	236·3	228·8	213·3	0		
10	254·2	247·7	240·7	232·0	225·4	217·5	210·5	204·6	195·8	193·8	0

Here again, then, the current density proper to be used to obtain maximum economy is not constant. It not only diminishes as we go further along the tapered conductor, but at any one point is the less the greater the total length of the line.

In the discussion which followed the reading of the paper,

Prof. G. **FORBES** considered that the paper just read had materially advanced our knowledge of the subject. He protested, however, against the way in which Sir William Thomson's law had been referred to; the latter had not, he thought, been fairly dealt with. The law as originally stated dealt with a particular case, and the law as laid down by Professors Ayrton and Perry was a modification of the same for a particular stated condition, and it could not be considered as a correction of Thomson's law. There were a great many points which require to be taken into consideration in working out the general problem of the calculation of mains. He would point out that the cost of laying down the mains, *i.e.*, opening out trenches, filling in, &c., did not vary directly as the sectional area of the conductor. The size and cost of the dynamo was an item which did not come as a direct varying quantity. The problem dealt with by Sir William Thomson was totally different from that dealt with by the authors. With reference to the Table given he would point out that the great variation in the quantity, t, which would be met with in practice rendered the table of comparatively little value. He would state that it was a mistake to suppose that the Board of Trade limited the difference of potential to be used on the line of route, it was only in the houses that this limit was imposed.

Mr. R. E. **CROMPTON** drew attention to a numerical error in the early part of the paper, the value of r being given as ·051 when it should be ·51.

Dr. **FLEMING** said that in any installation when the number of lamps required was fixed, the maximum current was also fixed so that Thomson's law could be literally applied. In taking the interest according to this law, it was necessary not only to consider the cost of the conductor pure and simple, but also the cost of opening out and filling in the trenches, &c.

Prof. **AYRTON** pointed out that Mr. Crompton was mistaken in imagining that there was any numerical error in the paper, and that Mr. Crompton's mistake arose from his not observing that the loss had been calculated *per mile*, not for the whole length of the line. The word "total" used in the paper was perhaps a little misleading, but the "totality" referred to the loss in power from the two causes heating and wasted interest, and not to the loss for the whole line.

Prof. **PERRY** remarked that, although it was perfectly true that in Sir William Thomson's mathematical paper read at the British Association, he assumed the current fixed and said nothing about the potential difference at either end of the line, in Sir William Thomson's inaugural address where he used his own law for the electric transmission of power from Niagara, he started by assuming that the potential difference at the dynamo was 80,000 volts, and he also assumed that the potential difference at the far end of the line was also fixed. Now under those circumstances the law given by Sir William Thomson did not lead to maximum economy as was supposed.

A paper was next read by Professors Ayrton and Perry on "Some Problems in Telpherage." The authors showed mathematically the conditions necessary to ensure a uniform supply of power per mile on a telpher line of various lengths.

The meeting then adjourned.

Royal Society.

"Effects of Stress and Magnetisation on the Thermoelectric Quality of Iron." By Professor J. A. Ewing, B.Sc., University College, Dundee. Communicated by Sir William Thomson, F.R.S. Received February 24th, 1886. (Abstract.) Read March 11th, 1886.

This paper comprises a revised version of one submitted to the Royal Society in 1881, under the title "Effects of Stress on the Thermoelectric Quality of Metals, Part I.,"[*] along with much new matter. It deals principally with the cyclic changes of thermoelectric quality which an iron wire undergoes when exposed to cyclic variations of stress (described in the abstract of the former paper), and with the relations of these changes of thermoelectric quality to the changes of magnetism which also occur as an effect of stress. Stress was applied by exposing the wire to longitudinal pull by means of loads. The changes both of thermoelectric quality and of magnetism exhibit that tendency to lag behind the changes of stress to which in a previous paper[†] the author gave the name *hysteresis*, and the effects are sufficiently similar in regard to the two qualities to suggest that the changes of thermoelectric quality occur as secondary effects of changes of magnetism. To examine whether this is the case, simultaneous measurements of the magnetic and thermoelectric effects of stress in an iron wire were made, and also independent observations of the thermoelectric effects of magnetisation, without change of stress. A comparison of these made it clear that stress causes change in the thermoelectric quality of iron directly, and not as a secondary effect of magnetisation. If the wire be completely demagnetised to begin with, and kept clear of all magnetisation during the application and removal of stress, the presence of hysteresis is not less marked than before. Experiments are given to show how the thermoelectric effects of stress are modified by the existence of more or less magnetisation in the wire; and conversely, how the thermoelectric effects of magnetism are modified by the existence of more or less constant stress. The influence of vibration in destroying the effects of hysteresis is investigated, and also the result of exposing the wire to the process of demagnetising by repeated rapid reversals of a continuously diminishing magnetising force, and it is shown that this process acts in the same way as vibration in destroying the effects of hysteresis. Residual effects of hysteresis are studied, as, for example, the difference which presents itself when a wire is magnetised after having been loaded strongly and then unloaded down to a certain constant state of stress, and, on the other hand, when the same state of stress has been produced by simply increasing the load; and it is shown that these residual effects are wiped out by vibration or by demagnetising by reversals. With regard to the effects of stress on thermo-electric quality, it is shown that if a somewhat soft wire be more and more strongly magnetised, these effects become more and more similar to those which are found when the wire is hard-drawn, but not magnetised. A few experiments were made with wires of silver, copper, lead, magnesium, and German silver, but in none of these was hysteresis of thermoelectric quality with regard to load discovered.

Special attention is directed to a peculiar feature in the curves by means of which the experimental results are exhibited. In curves showing the relation of thermo-electric electromotive force to load, it is shown that any reversal from loading to unloading, or *vice versâ*, causes an inflection in the curve, the first effect of the new process being to continue the kind of change of thermoelectric quality that was going on before. That this is not due to any mechanical disturbance which the loading or unloading produces, is shown by the fact that it occurs in an equally marked way after the molecules have been brought to a condition of stable equilibrium by vibrating the wire before beginning to load or unload. It is suggested that the effects of hysteresis, described in the paper, have a possible relation to the properties which Prof. Osborne Reynolds has recently shown to be possessed by granular media.

The experiments described in the paper are closely connected with those which were communicated to the Society in January, 1885, under the title "Experimental Researches in Magnetism," and are now being published in the *Philosophical Transactions*. They were conducted in the Physical Laboratory of the University of Tokio, in 1881-3, partly with the help of one of the author's Japanese students, Mr. S. Sakai. The results are given graphically, and are for the most part reduced to absolute measure.

NEW PATENTS—1886.

3360. "Electric alarm clock." J. Warmisham. Dated March 10.

3418. "Protecting or insulating wires used for conducting electric currents." M. Settle. Dated March 11.

3448. "Method of shot-firing and blasting in mines by the agency of electricity." F. Brain. Dated March 11.

3475. "Dynamo-electric machines." R. E. B. Crompton. Dated March 11.

3476. "Galvanic batteries." A. Schanschieff, G. R. Fludder. Dated March 11.

3499. "Small-sized switches to be used in electric lighting circuits." G. Lowdon. Dated March 12.

3508. "Electric light fittings." R. E. B. Crompton, W. A. Kyle. Dated March 12.

3516. "Holders or supports for incandescent electric lamps." A. Swan. Dated March 12.

3535. "Acoustic telephones." H. G. Ellery, J. T. Gent. Dated March 12.

3554. "Dynamo-electric machines." W. Hartnell. Dated March 13.

3556. "Making sugar by electrolysis. E. Fahrig. Dated March 13.

3568. "Induction cables." A. Vogt. Dated March 13.

3577. "Depolarising electric batteries." A. C. Henderson. (Communicated by E. Bazin.) Dated March 13.

3587. "Vibrating electric motors." A. L. Parcelle. Dated August 11, 1885. (*Complete.*)

3598. "Electrical switches." H. W. Edlin. Dated March 13.

3540. "Electric fuse for blasting purposes." A. M. Clark. (Communicated by Scola et Ruggieri.) Dated March 12.

3605. "Means or apparatus for producing and regulating or controlling electric currents." J. Y. Johnson. (Communicated by E. A. G. Street and A. L. W. Desruelles.) Dated March 13.

3657. "Electric incandescent lamps." E. Edwards. (Communicated by E. Herrmann.) Dated March 15.

3670. "Electric incubator and foster-mother." H. Neumann. Dated March 16. (*Complete.*)

3726. "Galvanic batteries." H. H. Lake. (Communicated by J. Serson.) Dated March 16. (*Complete.*)

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1885.

992. "Improvements in electrical motors." R. A. Lee and J. E. Chaster. Dated January 23. 8d. Consists generally in constructing the revolving armature of considerable diameter in proportion to its width, in combination with improved field-magnets. The armature is a ring form made in the softest iron. It is divided into six or more equal divisions, which divisions are parallel in themselves, and at right angles to the centre of motion, and upon which the necessary wire is wrapped. One of the several features is, that the divisions that are opposite have parallel sides, that is the outside and inside edge of the ring are parallel with themselves, and likewise parallel to the two sides of the division opposite, thus allowing the wire that is wrapped thereon to be very evenly laid coil upon coil. The coils of wire on each section are also stepped off each other, so that a considerable air space is left between one section of wire and its neighbour, thus allowing a free ventilation, which prevents the motor from becoming heated.

2833. "New or improved applications of electro-magnetism to arm chairs, seats, carpets, or other articles of furniture to produce a magnetic bath or medium." W. L. Wise. (Communicated from abroad by G. Edard, of Paris.) Dated March 3. 8d. Has reference to the application of electro-magnetism to carpets, armchairs, beds, couches, seats or other articles of furniture for subjecting sick persons to the influence of a magnetic medium, the composing elements of which are excited by the passage of a current proceeding from a generator of electricity of any suitable nature.

2896. "Dynamo-electric horse clipper." C. de Salazar. Dated March 5. 8d. Consists of fixing to ordinary horse clippers or others of more suitable size, between the handle and the scissors two induction rings with electric motor, this new disposition allows also for diminishing the weight and size of the clipper. The circular rotary movement caused by the electric motor is transformed into and gives to the scissors an alternating rectilinear motion by a system of articulating levers which diminish and regulate the speed of the motor and scissors which otherwise would be too great, and this also allows for considerable increase of power in the clipper. This motor can be kept in action by any ordinary electric battery, which may be attached to or carried by the person using the clipper.

3888. "Improvements in the manufacture of electrical batteries." L. P. Merriam. Dated March 26. 4d. Consists in forming the joints of the troughs by means of xylonite or other pyroxylin compound which is not affected by ordinary battery solutions or liquids.

14891. "Improvements in the transmitting of Farquharson and Lane's electric ship's telegraph." W. Skinner, J. Farquharson, and D. W. Lane. Dated December 4. 6d. Consists generally of a method of utilising stored energy for actuating the mechanism of the transmitting instrument at a uniform rate and at the maximum speed which can be utilised in the recording or receiving instrument by which means an important advantage is gained as the sender of the signal is free to attend to other matters while the signal is being transmitted.

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[*] Published in abstract in *Proc. Roy. Soc.*, No. 214, 1881.

[†] *Proc. Roy. Soc.*, No. 216, 1881, p. 22.

CORRESPONDENCE.

Secondary Batteries as Regulators.

Since writing last week, I have thought it not out of place to add a few words to show the relation which exists between the cells and line when charging. In doing this it is not my intention to give remedies, or to investigate some other points which might enter upon the question. My object is merely to give the relation, and to show that true regulation cannot exist, although it may be an approximation if well adjusted.

Let the resistance of the line be n times that of the cells. Then all variable current, *i.e.*, current above the normal due to variation in speed or from other causes; will divide between cells and line as $1 : n + 1$ and $\therefore \frac{1}{n+1}$ of all such variable current will go to line, and, consequently, the variable E.M.F. altering in this proportion. Clearly when n is large the regulation will be good, for $\frac{1}{n+1}$ will be small, for it must be assumed that the variations at the terminals of the dynamo will not be large, say 2 per cent. to 5 per cent., at most. Now, as n gets smaller the regulation gets worse.

In other words, the more lamps turned on the worse will be the regulation.

Again, the *curve* of a shunt machine is a falling one, so that when few lamps are in use they will be rather brighter than when many are on (this is the case whether *cells* are used or not, and can easily be shown theoretically, as well as practically), and if the light given by a lamp varies as $K\ C^6$, where $K =$ a constant and $C =$ the current, it is clear that pulsations in the light will be greater as the number of lamps are increased.

Now, when a lamp is bright, and becomes brighter, the difference is less perceived by the eye than when less bright and it becomes brighter. From this cause arises the difficulty of using the eye as a photometer for bright lights. Hence two things combine to give unsteadiness to the light when the number of lamps in use are continually increased in number. Firstly, $\frac{1}{n+1}$ gets smaller; secondly, the light pulsations are greater; and thirdly, the E.M.F. of the lamp circuit is lower, and in consequence the variations become still more marked to the eye. These remarks practically cover the ground. To assist "installators" in putting this to the test, it may be assumed that a 50 cell battery of 12-plate E.P.S. cells, with leads and connections, has a total resistance of 0·3 ohm, for with 10 per cent. E.M.F. above the counter E.M.F. of the battery 30 ampères pass. Values for n can always be found by taking a series of cases in which a given number of lamps are alight. The variations of E.M.F. can then be calculated and connected with the *curve* of the dynamo. If this latter is a good one, the *curve* will be practically a straight line within the capacity of the installation, and no further correction will be needed.

David Salomons.

Broomhill, Tunbridge Wells,
March 15th, 1886.

Dolbear and the Telephone.

Prof. Dolbear's analysis of existing telephone systems in your issues of February 12th and 19th is both clear and to the point. Mr. A. R. Bennett's letter of 5th inst., showing that he was independently at work on two receivers mentioned by Dolbear, has induced us to make public our claim also to having designed a battery transmitter, which we thought at the time was entirely new. Under the heading of "Dolbear's System, No. 1," the professor describes a battery transmitter which serves the double function of generator and controller of the electric current. An identically similar instrument to this we made in the early part of last year, with the exception that ours appears to have been larger than his. Though our cell was made as thin as possible, with the double object of gaining any advantage there might be by vertical as well as horizontal displacement of the liquid by the vibration of the diaphragm-element, thereby reducing and increasing the resistance two-fold, it was not so successful as we had expected. The professor does not seem to have been quite satisfied with its transmitting powers, for, referring to the distinctness in the receiver, he says, it was "*nearly* sufficient for every one"—an expression which is somewhat vague. We used a thin iron plate as vibrating element and a solid zinc plate as the other element, with a solution of caustic potash, choosing this excitant on account of its not attacking the iron. Our experiments with this instrument gave some very curious and unexpected results, and eventually led us to considerably modify its construction; and we are now, we believe, in possession of a novel and completely different instrument, particulars of which we hope shortly to be in a position to make public.

Coates and Macdonald.

Bow Electric Works, Bow, E.,
March 11th, 1886.

The General Distribution of Electricity by Continuous Current Transformers.

From the results of the remarkable experiments recently conducted on the Edison-Hopkinson dynamos, and which you described in your last issue, I should like to suggest that we have the password to an almost direct, continuous current distribution system. Let us suppose a high potential generator outside a supplied area, which is divided into a number of smaller districts, and that in the circuit of the generator are a number of motors in series with one another, a motor being in each district, and driving a corresponding but low potential generator which supplies a working current to the district. Each of these district motors and generators must be capable of supplying a constant potential with a varying consumption in its own district, and of not being affected by, or affecting the potential of, any of the other districts. This may be attained by governing the high potential generator to maintain an absolutely constant current in the motor circuit, so that the armature of each motor in the series will always have the same number of ampères passing through it, whether the other motors are running or not, and whether their counter E.M.Fs. are great or low, thus rendering each district entirely independent of the others. The speed, however, of each motor has still to be regulated to drive its generator, so as to maintain in its district a constant potential with varying consumption. This might, perhaps, be accomplished by winding the generator for constant potential with constant speed, and the motor for constant speed with constant current; but as the motor and generator would be running at the same speed for one lamp as for 1,000, and as I do not know that the dynamo will at present regulate itself sufficiently with such different loads, I prefer to use simple shunt-wound motors and generators, and to regulate the speed of the motor by varying its magnetism. Suppose the full current to be passing through the motor armature, if the magnets are inert no movement of the armature will take place, if feebly magnetised there will be a corresponding movement of the armature, the power and speed increasing as the magnetism increases. The magnetism may be varied by means of a variable resistance in the shunt, and controlled by an electric governor influenced by the potential in the mains of the district. So that thus each district automatically maintains its motor only at that speed that is exactly suited to its immediate rate of consumption; the main generator automatically accommodating itself to the amount of power and light required in the whole system.

It is evident that the same method of distribution and of regulating the motor is applicable to electric rail and tramways. If the power supply, such as a waterfall or tidemill, is a great distance from the town or supplied area, the high potential current might be transmitted by relays, or a chain of coupled motors and generators, and when we have arrived at the use of very high potentials, and but a little more efficiency in the dynamo, with little loss on the way.

G. E. Dorman.

Stafford, *March* 14*th*, 1886.

Secondary Battery Indicators.

I have carefully read Mr. Sellon's specification as given in his letter in your last issue, and must say, with all due deference to that gentleman's valuable invention, that I fail to see how it anticipates the perfected arrangement patented by Mr. Parker in 1884.

In the first place, ascertaining the state of the charge in the secondary cell by measuring the specific gravity of the liquid had, we all know, been suggested and practised before the date of Mr. Sellon's patent.

In the second place, the designs shown in figs. 1 and 2, and fully described by Mr. Kent, *would not work*, because *any change* in the density of the liquid, sufficient to cause the bulb to move *at all*, would send it right to the top or the bottom—whichever it happened to be—as there is nothing to stop it, unless the "*fine* wire of glass or of platinum" is supposed to displace so much of the solution that it would act like an ordinary hydrometer. If the latter be the case, then the accuracy of the measurements indicated must depend upon the liquid being maintained always at an exact level in the cell, and I do not think there are many "gardeners" who could be depended upon to keep this level always constant.

Mr. Sellon's arrangement, shown in figs. 3 and 4, also depends entirely upon the level of the solution in the cell, and I feel sure the "gardener" would be too "heavy handed" to adjust this always—even to one point of decimals—and a variation of one-tenth of an inch might cause much over charging.

Mr. Parker's claim is for a simple form of hydrometer, which is not influenced by changes in the level of the liquid in the cell, and correctly indicates the density, so long as the bulb (which is of considerable size in order to make the indications very accurate) is entirely below the surface of the solution. The weight is increased or diminished as the arm carrying the balance weight forms a more or less acute angle with the perpendicular.

Mr. Sellon could obtain a similar, but I think a less accurate effect (owing to friction, &c.), by using what is called a fusee, instead of the pulley in his "wheel barometer" arrangement; but this would make it practically the same as what Mr. Parker claims.

P. Bedford Elwell.

March 16*th*, 1886.

The Meaning of Diaphragm.

"Telephonist" says that all the telephonic conferences in the world cannot alter the patent laws or limit the meaning of that wonderfully *flexible* and *elastic* word "diaphragm." How admirably put! But they can—or rather, common sense and judicial impartiality can—prevent that flexible and elastic article the "diaphragm" from being so distorted as to include things that are neither flexible nor elastic, and which, therefore, cannot be what Edison says his diaphragm must be, namely, of mica or other flexible material. The inventor never used or intended to claim anything more than that.

"Telephonist" is quite right: flexible and elastic.

"Inflexible."

London, 16*th March*, 1886.

Dynamo Testing.

The method of testing dynamos used by Captain Cardew seems to me to be the best yet introduced; but would it not be a more perfect test if the belt were dispensed with, and if the shafts of the two machines were coupled together as in Dr. Hopkinson's method? By this means there would be no unknown loss in the transmission of power from the motor to the generator.

The percentage of error in the test, due to the dynamometer used in measuring the energy supplied to the machines, has been greatly reduced by Dr. Hopkinson's arrangement; but I think this might be altogether avoided by using a current from another machine, or from secondary batteries, as suggested by Lord Rayleigh, to supply the extra power required.

W. E. Hayne.

March 16*th*.

Telephone Conference.

Because Mr. Irish made the proposition for a telephone conference, I do not think he deserves the onslaught of "Telephonist" in his letter to you, for it is notorious that there has long been a strong desire amongst electrical firms to wrench the monopoly from the hands of the one company now holding it. There is no chance to "run" anybody's telephonic patents in Great Britain without a very clear common-sense, as well as legal opinion, as to its being clear of the Bell and Blake patents, so that Mr. Irish's patents would, like other inventors', stand on their own merits. I think a conference of inventors and electricians would be of use, and, for one, would willingly take part in one within easy reach. Such a conference to discuss points, and exchange ideas for mutual benefit, and for testing suggested experiments, would I believe be of value. True, the Bell and Blake patents have only a few years to run, yet to get into the market before that for private work, if not for exchanges, is what is wanted, to say nothing of aiming at

Long-distance Telephony.

Charge and Discharge Indicators for Secondary Batteries.

Unless it be too early—with an experience of something less than a year—to offer an opinion on the behaviour of secondary batteries, I would venture to say, with reference to the present discussion in your columns, that, as an index of charge, the voltmeter is far preferable to the hydrometer.

The storage cells I use, are (like the dynamo) by Messrs. Elwell-Parker; and for the first few months their condition was estimated principally by the variation in specific gravity, checked by occasional observations with a two-coil "detector galvanometer." Tests were taken (1) by two instruments of the hydrometer-index pattern (illustrated at page 205 of the ELECTRICAL REVIEW for March 5th) permanently fixed over two separate cells. (2.) By a hydrometer specially made, of long scale, and thin enough to pass in any cell between the ends of two adjoining plates. (3.) By filling a pint jar with liquid drawn from various depths of the cell by a large glass syringe with long nozzle, and using a sensitive hydrometer. But the results were discordant, and sometimes contradictory. The reason probably is, that the change in specific gravity does not proceed uniformly throughout the cell: and that it is not practicable, without removing the plates, to agitate the liquid thoroughly, with a view to its examination by the hydrometer. Perhaps, too, the observations are vitiated by the addition, from time to time, of plain water to the cells, to replace what is lost by evaporation, or by the generation of gas. Moreover, the extent of variation in sp. g. is very slight, seldom more than 5° (*e.g.*, 1,125 before charging, and 1,130 after.)

In the exhaustive paper by Mr. Preece, F.R.S., published in the ELECTRICAL REVIEW, of May 28th, 1885, it is graphically shown how the progress of the charge of secondary batteries can be tested not only by the hydrometer, but by the alteration (the dynamo remaining constant in speed) of both current and E.M.F.—and, for my own part, I find this last to be all that is required. The gradual rise of E.M.F. during charging seems to be an unfailing indication of increased storage: at any rate, when a certain reading of the voltmeter (determined by previous trials) has been attained, no further efforts of the dynamo can augment it; and it is therefore fair to assume that this maximum E.M.F. corresponds to a full charge of the battery. For instance, the following is one of the entries for an afternoon's run. The attendant at the dynamo takes frequent readings of a voltmeter and ammeter in the same room with the machine, recording them every half-hour, and more frequently when the charge is supposed to be nearly complete :—

H.	M.	Revolutions.	Volts.	Ampères.
1	15	950	58	54
1	45	975	60	58
2	15	975	62	58
2	45	980	63	58
3	15	980	65	58
3	45	980	66	59
4	15	1000	67	59
4	35	1000	67	57

Previous experience had fully proved that when, as in this case, 25 cells were being charged, 67 volts is the maximum E.M.F. obtainable at about 1,000 revs. of the dynamo: consequently, when this reading has been repeated and maintained, the dynamo is always stopped.

Certainly, if hydrometric indications were reliable, they would afford a convenient estimate of the gradual *discharge* of a battery: but for this purpose, I find one of Mr. Ferranti's ingenious meters to give more accurate information, and without the trouble of seeking it in the battery room. The revolutions of the meter for a given period, when divided by its constant, are equivalent to the ampère hours discharged during that interval of time. And, on the other hand, to ascertain the number of ampère hours *put into* the battery on any occasion, it is only necessary (in the absence of a second meter, on the charging circuit) to take the average current for the specific time. For instance, in the above example, the supply from the dynamo may be taken at 57·5 ampères for 3·3 hours, or 190 ampère hours. Then, allowing a margin of rather over 10 per cent. of current (of course the loss in Watts is greater) it is a simple matter of subtraction to decide how many ampère hours should be available from the battery at any time. Practically, even that calculation is not needed, so long as the light required from the battery remains about the same, and, if the storage should be greater than it is supposed to be—and charging be resumed too soon—the voltmeter will soon reveal the state of affairs, and will tell the attendant that he may stop the dynamo sooner than he expected.

Thomas S. Bazley.

Athenæum Club, Pall Mall,
March 13*th*, 1886.

Mechanical Telephones.

Not much harm is done by the registration of the Mechanical Telephone Company with its very modest capital, and I believe it has a better chance of earning a dividend than many of the highly-vaunted electrical ventures of 1882-83. The absence of a cheap telephone worked by electricity has created a demand for mechanical ones for short distances. Whether the new firm can persuade the public to buy their particular articles is a matter for themselves. As yet I have not seen any prospectus; but it is evident, on the face of it, no large sums can be paid for the two patents of "Byng" and "Lee." Payment by results would appear to be the wisest arrangement. As it is, "Telephonist" may not have the opportunity of subscribing to the £5,000 of capital, which he hopes you will warn all and sundry against ruining themselves by.

Acoustic.

Telephone Patents.

I am somewhat amused at the marked desire of your correspondents to put me right upon my supposed want of information as to the action of the Valve transmitter, which somehow they fancy I cannot believe can possibly work without a diaphragm.

Mr. Sidney F. Walker (whom I was nearly referring to as Mr. *Duplex* Walker, seeing he speaks of "our," "I," "my," and "we,") after his little bit of instructive information goes at once to the question of the working of the New Telephone Co.'s instruments, and as he has the reputation of being a practical electrician, his remarks should carry due weight and authority. Let us see how far his testimony accords with my previous letter. He says that his "experience with the same company's instruments has not been very fortunate," and gives his idea of the cause of these negatively stated bad results as "due to bad workmanship in the manufacture." That being so, I say, is but in strong support of the facts set forth by me in my previous letter, which despite of Mr. Secretary Barnard's attempted sneer, *were not* "*imaginative*" *statements but facts*, drawn forth by his rushing in to chide me for not making mention of, or rather ignoring the existence of, the New Telephone Company's telephones. He claimed for them a value which, when fitted up by their own representatives, they had not been able to make the instruments exhibit; and I but recited my experience, which had practical results in the loss to them of a good order, with more in prospect. It is most singular to note that whilst Mr. Barnard refers to a list of testimonials, that in the case of Mr. Walker and the one I referred to, the inspectors sent down were unable to make the instruments work properly; for if you place a good instrument into incompetent hands it might fail, indeed, the probability is that it would; but a badly-made article was rendered less efficient by clumsy handling, so that whilst Mr. Walker closes by saying he believes the instrument is a good one, his letter convicts them of bad workmanship and inefficient inspectors.

The gratuitous advertisement sought for and obtained by Messrs. Jno. Barrett & Bros. takes off somewhat from the value of their testimony, whilst the information that the line was erected before the instruments were tried will be smiled at for its originality.

If "Telephonist" will re-read my letter, he will see I did not blame the transmitter. I gave results from the set of instruments, and wanted to know *where* the cause lay of only getting Punch and Judy talk.

When first I wrote you I had no idea the discussion would have drifted as it has done, thanks to Mr. Barnard. Next week I may endeavour to bring back into its proper channel the question started by

"Combination."

"Self-Induction."

What—in the name of all the mysteries to be revealed through an attentive study of the phenomena presented by helical conductors—does "A Coil" mean by saying that "Prof. Fitzgerald," in the discussion upon Prof. Hughes's paper, "proved the existence of magnetism before it was born"? As only one person of that name spoke during the discussion in question, the individual referred to must be your humble servant. But, on a careful perusal of the notes, taken by the shorthand writer, of what I did say, I fail to find anything that could have inspired the above view. And, if the latter be a joke, I fail also to see the point of it. Perhaps that may be because what is "writ so sarkastic" here applies to myself; for I can not only understand but to a great extent sympathise with the main purpose which underlies your correspondent's letter.

Perhaps what he means to say is that I proved the existence of a maximum of magnetisation in the conductor prior to the passage of the normal current, and of *some degree* of magnetisation prior to the passage of *any* current. In this case—to use the expression of "My little Sweetheart's" favoured suitor—he *flattens* me! I did not prove it; but I suggested it. There was no time at my disposal to prove anything, without preventing other speakers from having their say. But with your permission, Mr. Editor, I will send you a paper embodying what I meant to say, and what probably I should have said, had the occasion been more favourable. I may assure "A Coil" that my communication will have the negative merit of containing no complicated formulæ.

Desmond G. FitzGerald.

Every listener present at the discussion which followed Prof. Hughes's most excellent paper cannot have been quite so ignorant as your correspondent "A Coil," who declares that "one and all" of the "professors" who took part in the discussion made the coefficient of self-induction "*in a coil*" the burden of their song. I was present at the whole of the debate, and heard the following professors speak, viz.:—Lord Rayleigh, G. Forbes, J. Hopkinson, J. A. Fleming, S. P. Thompson, and W. E. Ayrton, and, unless I am very greatly mistaken, they "each and all," when speaking of the coefficient of self-induction, dealt with it not in relation to coils at all, but in relation to circuits in general, and particularly in relation to straight conductors such as Prof. Hughes had been using. The algebraic expression which Lord Rayleigh wrote upon the black board (and which, because it was quoted from Maxwell's treatise, seems to have excited a current of self-induced anger in "A Coil"), was an expression for the self-induction of a circuit consisting of *two parallel straight* wires, and was stated in terms of their length, thickness, and distance apart! Probably it is, to a person so devoid of a knowledge of simple algebra as "A Coil," an easier matter to copy out of Wiedemann's treatise a complex formula relating to something that never came into discussion than to understand the very simple formula for straight conductors which Lord Rayleigh set before him; he didn't even take the pains to notice that it was a formula for straight conductors and not for coils. No wonder he didn't grasp Lord Rayleigh's other point that "the self-induction" in a circuit was a different quantity from "the coefficient of self-induction" of that circuit. Perhaps "A Coil" is not aware that "the magnetism" in a bar of iron is a different quantity from "the coefficient of magnetisation" of that bar. Perhaps "A Coil" would be surprised to learn that "the interest" which he may receive on a sum deposited is a different quantity from "the rate of interest" by which the amount is calculated. But as his mathematical abilities are of so mean an order as to preclude him from understanding even what Lord Rayleigh's elementary algebra related to, it is probably useless to explain to him the point that is vital to the understanding of everyone of the experimental results obtained in Prof. Hughes's research.

"A Coil" says, quite truly, that "the President in his paper never attempted to prove the coefficient of self-induction in a coil;" the only allusion to the coefficient of self-induction in a coil is due to "A Coil" himself. "Here's a coil," indeed! If "A Coil" will but shuffle off his tortuosity and become a straight conductor he may perhaps be induced (mutually induced, perhaps, if not self-induced) to join circuit between the experimenters and the mathematicians—between those who dig for treasure and those who analyse the treasures so dug up. But if he would do this, he must have the patience to try to understand what words mean; and when he hears a professor say, "Let l stand for the length of the straight conductor and r for its radius," he must not jump to the conclusion that the professor is talking about "a coil," but must have enough patience to think that the professor really means that the conductor, though straight, can have a radius of its own. If he will think a little more he will then perhaps begin to understand how a straight round wire can have a radius; and then, perhaps, though it is rather a harder task, he may some day grasp the very elementary notion that a straight wire when joined in a circuit may have a coefficient of self-induction too.

A Professor.

Primary Batteries.

Allow me to reply to the paper on a Safety Lamp, read by Mr. Swan at the Glasgow Philosophical Society. Mr. Swan directed attention to the power of the combination of zinc-dilute sulphuric acid, peroxide of lead, as a primary battery, and said that this combination was entirely neglected since it was proposed, forty years ago, by De la Rive.

I tried in 1884 and 1885 different forms of that battery, and obtained results which would perhaps interest your readers.

I made, firstly, a battery with zinc—dilute sulphuric acid—and peroxide of lead—lead. The peroxide was obtained by action of nitric acid on minium, and maintained by means of asbestos. The electromotive force was very low (1 volt), and the cell rapidly polarised. This seems singular; zinc accumulators when charged are quite similarly constituted, and give 2·5 volts. I put then the electrodes of the battery in connection with three Bunsen's cells, as to charge an accumulator, and after a few minutes the electromotive force was 2·4 volts, and remained constant till all the peroxide was reduced. The current was about constant (1 ampère) for plates of 4 inches by 8. In that battery the thickness of the coating of peroxide was about one millimetre.

I made then a cell with zinc—dilute sulphuric acid and peroxide of lead, of the same quality as previously, deposited on a plate of solid carbon, and maintained by means of asbestos; I had immediately an electromotive force of 2·3 volts, but the current was not quite constant, and after having worked some time (two cells on a 4 volts 1·5 ampère lamp) the appearance of the positive plate was very curious. A layer of sulphate of lead, mixed with peroxide of lead, was formed on the exterior surface of the peroxide and also on the carbon plate; the peroxide coating was then quite insulated of the plate and liquid, sulphate of lead being a very bad conducting material. This may be the cause of the inconstancy of the peroxide of lead cells with carbon plates and dilute sulphuric acid.

The production of sulphate of lead on the surface of the peroxide coating, and also on the carbon, is perhaps due to the little conductivity and great porosity of the carbon employed; it would be quite avoided by using another liquid. I tried, without success, chloride of sodium, sal ammoniac, which give sub-products, with the peroxide of lead resulting from the electrical action. Chloride of zinc, only, gave good results; it must be employed in solution at 80 per cent., then no local action is to be feared at rest, resistance is somewhat higher than with dilute sulphuric acid, electromotive force is 1·9 volts, constancy is not absolute, but the depolarisation at rest very rapid.

When we use a zinc—chloride of zinc—peroxide of lead-carbon battery, peroxide of lead obtained by electrical action, electromotive force is 2·1, and current constant.

The preceding results seem to prove that the molecular constitution of the peroxide of lead is an important factor as regards electrical action, and a crystalline form is the best, conductivity and easy decomposition being then very high.

J. W. Dierman.

University of Ghent,
March 8th, 1886.

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